8170 Structure of the Lithosphere TREPHAL PARAMETERS OF THE OCEANIC LITHOSPHERE ESTIMATED FROM GEOID MEIGHT DATA A. CESSONYS, B. LEGO AND E. Dowley Communications

THERMAL PARAMITERS OF THE OCEANC LITHORPHERE ESTIMATED FROM GROUP BLIGHT DATA

A. Carsonava, R. Lago and K. Bominh (Groups de Rechstches de Odochéale Spatiale, Centre Estimai d'Études Spatiales, 18, Avenue Mosard Balin, 10015 Toulouse Cédan - France)
Goold beight nammalies derived from SEARIX Stituaces data have heat neelysed scross Fracture somes and over ocean ridges in two limited regions of the South Pacific (Eltanin fracture some system : East Pacific of 1chospharic cooling paralics on the plans model of 1ichospharic cooling paralics on astimation of the thermal parameters surveing in the model. Two quantities can be derived: the product or v Ts (v, thermal siffusivity : q, volume coefficiant of thermal) expansion: I m, bottom boundary temperature) and the thickness of the glate. The heat fitting values for the South Pacific and the Southeast Indian Casma are: 1 or Ts = 0.53 x 10<sup>-3</sup> code<sup>-3</sup> and B in the range 50-70 km for agas Least than 10 my whereas for larger ages (J 30 syr), geoid observations are better explained by a larger B value, is the range 70-90 km. The depth-age relationship observed in the South Pacific region is consistent with these parameters, On the other hand, Cast for the Northanst Pacific argue racher for a lithospheric thickness larger than 100 km. This suggment properties of the oceanin lithosphere.

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#### Volcanology

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SERNATIONS OF FOLCABIC TREMOR AT HT. ST. BELENE

VOLCAND

A. Pahler (Geophysics Group; School of Oceanography,
Oragon State University, Corvalifs, Oragon, 9731)

Digital recordings of ground motion during eramor
opisodes accompanying eruptions at Ht. St. Balens Volcano in the arsa of Vashington on August 7 and Octabor 16-18, 1980 are studied. The spectra of the vercinci component waveforms contain at least two deadnant pasks at 1.0 and 1.3 Es for all events recorded
during both eruptions that were studied. Spectra of
horisonal ground motion show peaks at .9 and 1.1 Hs.
The rolative amplitudes of the two peaks changes butures tramor apisodes and during single tramor episodes and show no consistent relation to amplitude
of ground motion. Spectra of lees period earthquakes and show no consistent relation to amplitude
are very similar to those of tremor synta suggesting
that tremor is composed of many long period earthquakes that occur ovar a pariod of time. The unique
waveforms of tremor swents observed at Ht. St. Salams
must be due to a source effect since the relative
suplitudes of the two dominant peaks change during
tremor spinodes. The parts effect on tremor waveforms
is small since there are no peaks in the spectra of
avaveforms recorded during tectonic earthquakes occurring in the vicinity of Rt. St. Balums. The conmistancy of time location of the spectral peaks for
alternative recorded during tectonic earthquakes occurring in the vicinity of Rt. St. Balums. The conmistancy of time formor smplitudes means that there
assume the remain of the suplitudes of motion at the
courtes. Variations in smplitudes of motion at the
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torvalis, Oragon leads to the conquestion of the supliced of
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8699 Yalcanology RESUSPERSION OF WULCANIC ASII FROM MT. SI. MELFNS P. V. Hobs (Cloud and Agrosal Research Group, Almospheric Sciences Dopt., University of Research (1988), D. A. Negg and I. F. Radke

Radke

Measuremonts are presented of the sign spectra of ash particles, previously deposited on the ground from the 18 May 1900 eruption of Mt. St. Heldens, that more resuspended into the dir in Eastern Washington. It is concluded that winds of just a few maters per socond were capable of rasuspending most of the smaller ash particles and that this caused dramatic reductions in visibility.

J. Geoghys. Ras., Green, Enper 201927

particles and that this caused dramatic reductions in visibility.

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8699 Volcanology
MAGMA RESERVOIR SUBSIDENCE MECHANICS: DMEORETICAL
SURMARY AND APPLICATION TO KILAUEA VOLCANO, HAMAII
M. P. Ryan (959 National Canter, U. S. Geological
Survey, Reston, Virginia 22092), J. Y. K. Blevins,
A. T. Glamura and R. Y. Koyanagi
An analytic model has been daveloped for the
prediction of the three-dimensional deformation field
generated by the withdrawal of megas from a sill-like
storage compartment, during an intrusion or eruption
cycle. The model is based on the work of Berry and
Sales (1961, 1962) and predicts the vertical displace—
ment components over the areal plane. Model parameters
are the depth of burial (h), the intrusion half-largeth (b), the thickness of
the magmatic interior at the moment of melt withdrawal
(a); the intrusion half-largeth (b), the thickness of
the magmatic variations in model parameters within the
context of Kilauea Volcano, Hamesi, have revealed that
circular and elliptical deformation patterns result
from the tollapse of draining rectilinear intrusions at
depth. Horeover, the geometric parameters of a storage
compartment may interact in complex ways to produce
similar deformation patterns. The model has been
applied to Kilauea Volcano for three periods of pronounced summit subsidence: (1) 1921-1927 (bracketing
applied to Kilauea Volcano for three periods of pronounced summit subsidence: (1) 1921-1927 (bracketing
the steamblest eruptive phases of 1924) (2) June 1972

December 1972; and (3) December 1972 - Agy 1973.

Application of the model requires the simultaneous
optimization of five predicted deformation features,
with respect to field measurements and the derivative
deformation maps: (1) the vertical displacement maxima;
plane; (3) the lateral extent of the deformation field;
the super tratio of the major axis of the deformation
field. The constrained geometries and volumes of the
are; il 1921-1927; depth, a, &m. a 1900 m, b # 4500
m, t # 20 m, y

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# General or

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AN GALECTIVE PROCESSER FOR DEFECTIVE AND CONTROL ERRORS IN GEOPHYSICAL DATA: 2. NOLTHERESONAL APPLICATIONS
H.R. Elming (Nether-AN CHARCTIVE PROCEDURE POR DETECTION AND COMPANY RESPONDS IN CORPHISICAL DATA: 2. MUNICIPAL PROCESSION APPLICATIONS (National Oceania and Assospheria Administracion, National Environmental Rates (National Invironmental Rates) (National Invironmental Rates) (National Invironmental Rates) (National Invironmental Rates) (National Invitormental Rates) (National Rate **Mineral Analysis** 

*53*, 799, 1981).

# News

### Lasers: The **Femtosecond Pulse**

Laser applications in geophysics range from making hydrographic depth soundings to a myriad of types of spectrographic measurements on crystals and polycrystalline materials. Reducing the emitted pulse width is a recurring need in many scientific laser applications. In determinations of ocean bottom depth and of mean sea level by airborne laser systems, a pulse width of one nanosecond (10-9) is barely sufficient to obtain the desired accuracy (± 30 cm). In crystal physics measurements, a pulse width of about one or two picoseconds (10<sup>-12</sup> s) is required. An object of these specifications is to be able to operate at the time periods of ionic and molecular vibrations. It should be possible to study excitation and kinetic processes in a condensed material before they have relaxed or otherwise come to equilibrium.

According to a recent study at Bell Laboratories, researchers have now split the picosecond by producing an emitted-light pulse width of 30 femtoseconds (10<sup>-14</sup> s, during which light travels a distance of about 0.3 μm) from a new colliding-pulse ring dye laser system (Physics Today, December 1982). This laser uses nonlinear optics to 'chirp' the pulse, a technique something conceptually similar to techniques employed in geophysical applications of radar delay-line pulse generaiors. That the production of a femiosecond pulse represents a 'real' state of the art is evidenced by the fact that such a pulse is too short to measure by conventional techniques Techniques that in effect use the pulse to measure itself are necessary (Ultrashort Light Pulses, S. L. Shapiro, Ed., Springer-Verlag, New York, 1977).

The chirping method of compressing microwave pulses is done by superimposing a linear frequency sweep on the carrier frequency. The method for compressing picosecond optical pulses derives the same result but the chirping process to produce a timedenendent shift of the carrier frequency is done optically. As achieved by the Bell Laboratories group the system employs a monlinear optical fiber.

The process was first demonstrated a short time ago in nonlinear liquids. In these liquids the index of refraction changes in proportion to the intensity of light Laboratory The nonlinear refractive index term results when the electric field produced by very intense light is of the same magnitude as the liquid's intramolecular field. Thus a light pulse consisting of an intense peak with leading and trailing edge tails is 'self phase modulated, as there is a time-dependent shift of the carrier frequency. When an optical pulse is coupled with several tens of meters of single mode optical fiber, the pulse can be compressed in time. In the radar-microwave anal ogy the optically chirped pulse is fed through an optical delay line consisting of a dispersive grating system that allows the high-frequency end of the pulse to arrive in time with the lower-frequency leading edge. This optical-fiber and grating delay line system was initially described by H. Nakatsuka, D. Grishkowsky, and A. C. Balant of the IBM Research Labo-

ratory (Phys. Rev. Lett., 47, 910, 1981). The mode-locked, dye-laser systems, including cavity dumping and autocorrelation techniques to measure the final pulse width, are now available commercially though they were unknown a decade ago. The collidi pulse ring dye laser employed by Bell Labo-ratories is a new variant designed to enhance the mode-locking effect.

The new systems are an attempt to meet. two basic requirements of laser applications. High-power pulse widths that are extremely narrow in time provide the necessary precision for airborne-laser tracking systems. They provide the most intense way we have of interacting with condensed matter without destroying it, according to C. V. Shank of Bell Laboratories (Phys. Today, op. cit.). The state of the laser art now stands at a 30 femtosecond pulse that has peak power in the Gigawatt range.—PMB

# **XANES: Solid State**

Researchers in the field of mineral physics have become aware of new analytical techniques for studying the electronic structure of solids; one such technique is the X ray absorption fine structure (XFAS) method. In this technique the fine structure of the X ray K-edge, for example, can be employed as a critical probe of the intricacies of a crystal structure (P. A. Lee, P. H. Citrin, P. Eisenberger, and B. M. Kincald, Rev. Mod. Phys.

A similar, related technique, X ray absorp tion near-edge spectroscopy (XANES), is a relatively unknown method of studying the

electronic structure of solids. XANES is new, and due to its complex nature, data on all but very simple solids have not yet been applied rigorously. Among the first XANES results on minerals is the recent study reported by G. Knapp, B. Veal, H. Pan, and T. Klipper (Solid Sinte Comm. 44, 1343, 1982) on perovskites, magnesiowustites, and other 3d oxides in the zircon and spinel groups. The inter-pretation of these results is still semiquantitative, being based on ground state and basic selection rule considerations. The results show, however, a strong correlation between

near-edge spectra and crystal structure. XANES, a lower energy version of EXAFS, is concentrated within 30 eV of a given X ray absorption edge; in some instances the two techniques coincide. As described by Knapp et al., ... XANES directly probes unoccupied states of the photoionized ion which occur at energies near the Fermi level  $E_{F}$ . This study found that the near-edge spectral patterns of the phases containing 3d elements were es-sentially identical within a structure type, spinel, perovskite, rock salt, or zircon. The patterns were not dependent on the particular transition element even though the K-edge energies differed by several keV. Further, there was no dependence on differences in the occupied 3d electron populations ( $d^0$  to  $d^8$ ) were compared), but this result was consistent with dipole selection rules and was to be expected. The spectra are most sensitive to empty b states (above  $E_{x}$ ), but the change in the number of d electrons for increase in atomic number would have little effect as well. The spectra are unusually consistent though, considering the range of composition

In certain spectra there is some indication of band complexities arising from transitions to a p-d mixed empty state. The case, p-d orbital mixing, results from a lack of a center of symmetry in tetrahedrally coordinated

The results of the study by Knapp et al. indicate that the XANES technique can be used to deduce the valence states of cations. Their local site symmetry and coordination number can also be determined as characteristic. These results are important, because application of this new technique may pave the way to determining the coordination of ions in complex mineral structures for the first time. Numerous cases exist in rather common minerals where the coordination with oxygen of cations remains unknown or poorly determined. The technique, like XFAS, requires a very large X ray flux. XANES studies may be among the first mineralogical studies to be done with synchotron radiation when facilities become available.—PMB

## Awards Set For Study Abroad

#### Fulbright Program

Senior Scholar Fulbright awards for university teaching and postdoctoral research in 1984–85 are available in all academic fields for terms of 2-10 months in more than 100 countries. Applications and information may be obtained after April 15, 1988, on college and university campuses from the graduate dean, chief academic officer, or the international programs office. Interested persons also may write to the Council for Internation al Exchange of Scholars, 11 Dupont Circle, Suite 300, Washington, DC 20036 (telephone: 202-883-4985). Please specify the country and

field of interest. Deadlines for submission of applications are June 15, 1988, for American Republics, 15, 1983, for Africa, Asia, Europe, and the

Middle East.
The Fulbright program is funded and administered by the U.S. Information Agency.

#### Research in India.

The Indo-U.S. Subcommission on Education and Culture is offering 12 long-term (6 to 10 months) and 9 short-term (2 to 3 months) research awards for 1984-85. The fellowship program aims to open new channels of communication between U.S. and Indian academic and professional groups and to encourage a wider range of research activity between the two countries.

The fellowships, without restriction to field, include a stipend ranging from \$1200 to \$1500 per month, depending on academic and professional achievement and seniority; \$350 per month is payable in dollars, with the balance paid in rupees. In addition, an allowance is awarded for study and travel in India and for International travel, Long-term fellows also receive an international travel allowance for dependents of \$100-\$250 per month, in rupees, for dependents; and a supplementary research allowance of up to 34,000 rupees . . .

For additional information and application forms contact the Council for International Exchange of Scholars, Attention: Indo-American Fellowship Program, 11 Dupont Circle, Suite 300, Washington, DC 20036 (telephone: 202-833-4985). The deadline for application submission is July 1, 1983.

The program is sponsored by the Indo-U.S. Subcommission on Education and Culture and funded by the U.S. International Communication Agency, the NSF, the Smithsonian Institution, and the Government of

# **Geophysical Events**

This is a summary of SEAN Bulletin, 8(1), January 3, 1983, a publication of the Smith-sonian Institution. The complete Mt. St. Helens, Ol Doinyo Lengai, and Usu reports are included. The earthquake and meteorite fall reports are excerpts. The complete bulletin is available in the microfiche edition of Eos as a microfiche supplement or as a paper reprint. Subscriptions to the SEAN Bulletin are also available. For the microfiche, order document E83-002 at \$2.50 from AGU Fulfillment, 2000 Florida Avenue, N.W., Washington, DC 20009. For reprints, order SEAN Bulletra (give dates and volume number) through AGU Separates; \$3.50 for one copy of each issue number for those who do not have a deposit account; \$2 for those who do; additional copies of each issue number are \$1.00. For a subscription, order SEAN Bulle-tin from AGU Fulfillment. The price is \$18.00 for 12 monthly issues mailed to a United States address: \$28,00 (U.S.) if mailed elsewhere. Order must be prepaid.

#### **Volcanic Events**

Mt. St. Helens (Washington): New Jobe extruded onto composite lava dome. Kilanea (Flawaji): Major eruption in middle E Rift Zone may continue.

Long Valley (California): Scismicity declines: intense January swarm was accompanied by strains of 3-4 ppm and uplifts of up to 7 em in epicentral area.

El Chichón (México): Strong H2S emissions but no new explosions; cloud data to 76°N; unusual sumises and sonsers. Pacaya (Guatemala): Minor flank lava emis-

Santiaguito (Guatemala): Occasional explosions; rockfalls.

Costa Rica: Temperature and gas data at Poás, Turrialba, and Irazu.

Ol Doinyo Lengai (Tauzania): Vapor and tephra cloud Langila (New Britain): Several vulcanian ex-

plosions per day. Manam (Bismarck Sea): Little volcanic activi-

ty; steady, moderate seismicity. Ulawun (New Britain): Weak vapor emission; seismicity increases. Ruapeliu (New Zealand): Summit inflation

ends and crater lake temperature low; simi-lar pattern observed before hydrothermal eruptions in 1980 and 1981.

White Island (New Zealand): Abrupt defla-

Sakurajima (Japan): Increased explosive ac-tivity, ash ejection. Usu (Japan): Decreased seismic activity; negligible ground deformation.

Mt. St. Helens Volcano, Cascade Range, S Washington, USA (46.20°N, 122.18°W). All times are local (GMT - 8 h). Increases in SO2 emission, deformation, and seismicity preceded a series of small explosions and the extrusion of a new lobe onto the composite lava dome, the first since August 1982. The rate of SO<sub>2</sub> emission, which had re-

mained very low for several months, tripled between measurements on January 13 and 15 and remained between 60 and 110 tonnes/ day through the end of the month. About 20 small, shallow earthquakes were recorded January 17-18, but selsmicity declined and remained at background levels for the next 2 weeks. Heavy snow in the crater made deformation measurements impossible on the 5 and E sides of the dome, but very slow acceleration in the rate of outward movement of the dome's northern side began in mid-January. A few small gas and ash emissions occurred in late January.

Gas monitoring on January 30 showed that SO<sub>2</sub> emission had increased to roughly twice the rate of the previous 2 weeks, and SO<sub>2</sub>. Hux ranged from 170-260 tons/day through February 7, On January 3) a pronounced ac-celeration was measured in the outward movement of the corrhern side of the dome. Points on the western side of the dome, usually the area of most rapid outward movement, showed little such activity but sagged downward several tens of centimeters, A gradual, slight increase in the number of seismic eyents began February I, but seismicity remained relatively weak, reaching about the level of the January 17-18 activity.

morning, explosions sent plumes containing small amounts of ash to about 6 km altitude. A pilot reported that the cloud top was at 8 km altitude at 0015 on February 3. GOES East satellite images showed the plumes moving slowly toward the northwest. At 0430 a cloud about 150 km diameter remained centered over the volcano, but it had begun to diffuse 30 minutes later and by 0530 had reached nearly to Puget Sound, about 100 km from the volcano. Ashfall was reported at Olympia, near the S end of Puget Sound. During a predawn flight February 3, geologists observed that the explosions had created a small notch in the upper eastern flank of the dome. Within the crater the deposits from these explosions showed a complex stratigraphy. Rare breadcrust bombs were found at the top of the deposits. A laterally-directed component from one or both of the explosions melted snow on the crater's eastern floor and wall, producing a mudflow that reached Spirit Lake. The ash column from a third explosion on February 3 at 1728 reached about 4.5 km altitude. This explosion enlarged the castern flank notch to 60-100 m deep and 80-100 m wide. Deformation data of February 3 and 5 showed continued acceleration of outward movement of the northern side of the dome, reaching 5-6 cm/day by February 5. Visual observations showed severe deformation of the eastern side of the dome, where a large wedge of rock just south of the notch had tipped up and out several meters. Locatable seismic events stopped Febroary 5 and only events typically associated with steam emissions and tockfalls were derected during the next several days.

At 2389 on February 2 and 0256 the next

Late February 5 the USGS and the University of Washington issued an extended outlook advisory notice stating that an eruption was likely within the next week and could include some explosive activity. Poor weather prevented observations until about noon on February 7, when geologists observed the extrusion of a new lobe of lava from the floor of the eastern flank notch. It advanced mainly toward the east, filling the notch, and by atternoon had reached the top of the talus. pile at the base of the dome. From the air, geologists estimated that the new lobe extended roughly 100 in E-W and 50 m N-S. A small explosion occurred from the dome at

1640 on February 7. Weather conditions prevented access to the crater for the next few days, but seismographs recorded tockfall events, suggesting that the new lobe continued to advance. Glimpses of the dome beneath low weather clouds February 14 indicated that the new

lobe was still growing. Information contacts: Tom Casadevall, Chris Newhall, Donald Swanson, and Steven Brantley, USGS Cascades Volcano Observatory, 5400 MacArthur Blvd., Vancouver, WA 98661 USA; Steven Malone, Graduate Program in Geophysics, University of Washington, Seattle, WA 98195 USA; Dennis Haller, NOAA/NESDIS, Camp Springs, MD 20233

Ol Doinyo Lengai Volcano, N Tanzania (2.751°S, 35.902°E). All times are local (GMT + 3 h). On January 6 at first light (about 0600), Philip Sanders observed a cloud of vapor and fine tephra, not present the previous day, emerging from the volcano. During 12 hours of observation, the size of the plume gradually increased, but there were no audible explosions. Clouds obscured the summit the next morning and no additional observa-tions are available. Ol Doinyo Lengai's last re-

ported eruption was July-October 1967. Information contact: John E. Sanders, Depurtment of Geology, Barnard College, Co-lumbia University, 606 W 120th St., New York, NY 10027 USA.

Usu Volcano, Hokkaido, Japan (12.53°N, 140.83°E). Seismicity and ground deforma-tion at Usu ended in spring 1982, after 58 months of activity. The monthly number of recorded seismic events had gradually declined since the major eruption in 1977 (see SEAN Bulletin, 2 (8-9)), but remained above the background level through 1981, when approximately 308 seismic events were recorded per month (sec SEAN Bulletin, 7 (8)). Ground deformation had also continued since the cruption. The rate of uplift of the cryptodome decreased from about 2 cm per day in 1980 to about 0.8 in 1981. Northward lateral movement of the northern flunk also continued through 1981.

In 1982, seismic activity decreased to the background level of about 10 events per month by April: 496 events were recorded in January, 231 in February, 79 in March, 10 in April, and 11 in May. Ground deformation has been negligible since April 1982.
Information contact: Office of Volcanic

Observation, Scismological Division, Japan Meteorological Agency, 1-3-4 Ote-machi, Chiyoda-ku, Tokyo 100, Japan.

News (cont. on p. 84)

# The Oceanoaraphy Report



The Oceanography Report The focal point for physical, chemical, geological, and bio-

Associate Editor: Arnold L. Gordon, Lamont-Doherty Geological Observatory, Palisades, New York, 10964 (telephone 914/359-2900, ext. 325)

# Greenland Sea Ice/Ocean Margin

Miles G. McPhre

#### Introduction

One of the fundamental obstacles to understanding both weather and long term climate variability of polar and subpolar regions lies in knowing what controls the position and behavior of the boundary between open and ice-covered ocean, the marginalice zone (MIZ). Over the seasonal cycle, variation in sea ice coverage of the world ocean is about 25 million km2, roughly 7% of the total area; thus a significant portion of the ocean is at

some time during the year part of the MIZ. From the point of view of air-sea interaction, the MIZ is a very complex system; an interface between ocean and atmosphere with potentially extreme horizontal and vertical temperature gradients and large variations in mechanical properties. The 'joker-in-thedeck is, of course, sea ice-it modifies momentum transfer from the atmosphere; drastically alters surface albedo; serves as an efficient thermal insulator; damps surface wave motion; and, because it is relatively fresher than sea water, may substantially change both temperature and salinity structure in the upper ocean by melting or freezing. Sea ice is highly mobile in response to surface wind, capable of traveling tens of kilometers per day. It thus represents a negative source of both salt and heat that can be advected long distances across water-mass boundaries by atmospheric systems. It is estimated (e.g., Hibler, 1979) that fresh water exported from the Arctic Basin through Fram Strait as sea ice (about 10<sup>5</sup> m<sup>3</sup> s<sup>-1</sup>) is roughly comparable to the total continental runoff entering the basin. In this sense, the MIZ of the North Atlantic, despite its limited area, is the terminus

of a vast territorial watershed. Over the past decade, field experiments (notably the Arctic Ice Dynamics Joint Experiment) and theoretical modeling of sea ice and the adjacent atmospheric and oceanic boundary layers have dramatically increased our understanding of the behavior of ice-covered oceans. At the same time, there has been much interest in open-ocean frontal and mixed layer processes. In 1979 a workshop on the Seasonal Sea Ice Zone, organized by Wilford Weeks, provided the first systematic multidisciplinary approach to identifying problems faced in understanding seasonal sea ice and provided experimental techniques for addressing them (Audersen et. al., 1980).

In subsequent nicetings a research strategy was formulated from which emerged a structure known as MIZEX (Marginal Ice Zone Experiment). MIZEX is an international, interdisciplinary project aimed at studying spe-cific processes in the MIZ as part of a more comprehensive effort to understand how the annual and long-term variability of polar ice margins relate to large-scale atmospheric and occanic circulation (Untersteiner, N., Air-seake interaction research program for the 1980s, unpublished report, Applied Physics Laboratory, University of Washington, Sentde, 1985). The primary focus of MIZEX is the Greenland Sea ice edge in the region north and west of Svalbard, where most of the exchange between the Arctic Ocean and the rest of the world ocean occurs. The general research strategy, described by Wadhams et. al. (1981), includes field experiments planned for the summers of 1983 and 1984 (MIZEX 85 and MIZEX 84) (Johannesen, Hibler, et. al., in press) with follow-on winter inter, et. at., in press) with ronow-on winter and summer experiments later in the decade. Complementary work is planned for the ice edge in the Bering Sea (MIZEX WEST), as described in Eas, December 21, 1982, p.

#### Scientific Considerations

For conceptual and organizational clarity, the MIZEX effort has been broken into seven subgroups: remote sensing, meteorology, ice, oceanography, biology, acoustics, and model-ing. Some of the major problems and pro-posed work in each discipline are described low; more complete descriptions may be found in Wadhams et. al. (1981); and Johannessen, Hibler, et. al. (in press).

#### Remote Sensing

Given the extent and inaccessibility of areas affected by the MIZ, remote sensing is the only practical way of applying increased un-derstanding from experiments like MIZEX to long-term monitoring and routine prediction of ice-edge characteristics. Eddy-like structure long the ice edge in the Greenland Sea has been shown by LANDSAT image (see cover). Similar images have been anained with microwave sensors (e.g., Johannessen, Johannessen, et. al., in press), demonstrating the feasibility of all-weather, all-season remote observation. If MIZEX succeeds, for example, in providreasonable estimates of cross-edge hear and mass exchange in eddy or banding processes, then routine surveillance of such features will provide much improved estimates of large scale heat and mass budgets.

From an experimental standpoint, remote sensing provides the overall view necessary to identify special features for intensive study. Because persistent cloudiness is anticipated microwave sensors (SAR, SLAR, and Passive) will be used extensively. Studies of ice deformation obtained by tracking identifiable natural and artificial targets will complement buoy and transponder measurements.

There will also be a concerted effort to measure and understand the effect of changing surface conditions in the MIZ on scattering and emission properties.

#### Micteorology

The lower boundary of the atmosphere across the MIZ changes from a maritime regime, with low albedo and moderate temperature, to a highly reflective and, during much of the year, very cold regime. These changes, combined with dramatic variation in surface roughness, can impose large gradients in radiative fluxes, in surface stress, and in turbulent moisture and hear threes. Over pack ice, the boundary layer is usually stably stratified, with low, strong inversions. If this cold air is advected over open water with a strong temperature contrast, turbulence is in-tensified. By the same token, warm air advected over the cold surface is stabilized, with decreasing turbulence levels. Ice is generally thought to be rougher than the ocean surface, so that for the same surface wind and stability, turbulent drag over pack ice is greater than over the open sea; furthermore, roughness of the ice itself is often increased within the MIZ by rafting and pulverization. Sorting out these various effects presents a considerable challenge but is important for understanding how the ice and underlying water respond to the wind.

The MIZEX experiments will employ a variety of meteorological instruments for surface layer studies, deployed from ships and ice floes, along with aircraft boundary-layer measurements, radiosonde launchings, acoustic sounders, closely spaced surface pressure arrays, and buoy-mounted weather stations. An active atmospheric modeling component will complement the field measurements.

Sea-ice studies in the MIZ divide roughly into two classes: one concerned primarily with the thermodynamic growth, decay, and internal structure of ice; the other concerned with the mechanical properties of sea ice as a material affected by dynamical forces, mainly

Ice in the MIZ is broken into much finer individual floes and pieces than are found in the interior pack. Attenuation of surface wave energy by the pack ice is certainly a major factor in this break-up; gradients in other forces, such as horizontal current shear, may also contribute. These interstitial areas of open water not only change the mechanical properties of the ice, but also modify the radiation balance and the mean surface temperature sensed by the atmosphere. In summer, melt rates may be enhanced by increased insolation between floes; in winter, ice production is increased by continual opening and closing.

Water near the margin may contain more sensible heat than is usually found in the Arctic mixed layer, giving oceanic heat flux a greater role in the thermodynamic energy ance that controls ice thickness. The mass balance of ice regulates buoyancy flux into the oceanic boundary layer; thus, if oceanic sensible heat is available, the growth rate can serve as an important feedback parameter. Kinematics of ice motion in the MIZ are also of much interest. Buoy and satellite im-

agery studies indicate comparatively large

shear normal to the ice edge and divergence along the East Greenland Drift Current MI. ZEX will also study attenuation of inertial and tidal oscillatory motion.

Measurements planned include detailed studies of changes in mass, concentration. and floe size distribution, along with energy budget observations and properties of ice measured both in situ and cored for more extensive laboratory analysis. Radar positioning techniques and satellite navigation will be used to study kinematics of the ice drift field with an array of drifting buoys. In addition, mean motion, wave and collision accelerations, ablation, and other properties will be studied at the extreme ice edge, including eddies and bands.

#### Oceanography

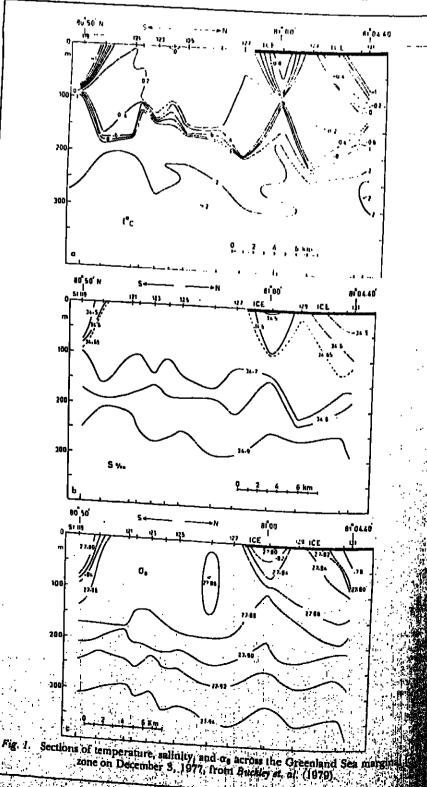
Modification of the upper ocean across the ice edge is often extreme, with large changes in temperature and salimity, large horizontal gradients in vertical density structure (with corresponding geostrophic shear), and rapid variation in surface momentum and buoyancy flux. At times, the MTZ coincides with the surface manifestation of a permanent, oceanic from (e.g., the East Greenland Polar Front), which may in turn be tied to a topographic feature (the shelf break); but as is the case in many marginal seas and in most of the Southern Ocean, the ice edge itself often forms a rapidly migrating, oceanic frontal zone. These from exhibit a variety of interesting features: eddies (see cover figure and nnessen, Johannessen, et. al., in press), fine structure (Paquette and Bourke, 1981), jets, and meanders. A summertime Soviet project at the Chukchi Sea MIZ noted a jet, directed along the ice edge so that open water was on the right, that persisted for the duration of the experiment regardless of wind direction (Nikolaev, 1973). The jet, which meandered on scales of about 90 km, probably resulted from geostrophic adjustment between rela-tively warm and saline water from the south and a lens of water freshened by ice melt.

Ice-edge upwelling and other mesoscale circulations appear in the M1Z; they are thought to be driven by surface gradients in stress or buoyancy flux. The Chukchi iceedge jet mentioned above seems to fall in the tarer class, since it was apparently independent of local wind. On the other hand,  $B_{\rm loc}$ hyer al (1979) observed a large upselling event north of Svalbard in early winter (Fig. ure 1), which they attributed to a surface stress gradient much like coastal apwelling. In this case it is hypothesized that seake, be cause of its greater upper surface roughness, amparts more momentum to its underlying boundary layer, causing Ekman divergencen the ice erige:

Boundary layer and surface layer process are also an active area of research. Rapid melting at the tee margin can yield in the upper occan an input of fresh water at a rate anparable to that of a torrential rainfall, creaming a stable boundary layer analogous to the northernal boundary layer of the atmosphere. McPho (in press) offers the resulting reduction in drag on the ice underside as an explanation for divergence of bands of sea away from the main pack under off-ice winds. Absorption and reflection of surface gravity wave energy is also a significant factor in the MIZ, invoked to account for the relatively sharp ice edge often observed. Wave radiation stress has also been suggested as a primary factor in the formation of ice-edge

nds (e.g., Wadhams, in press). An ambitions or canographic measurement program is planned for the MIZEX expenments, including current meter moorings. both bostom anchored and suspended from the surface; extensive hydrography from ship and helicopter; probling current metersatems; houndary layer turbulence measurements; expendable temperature and velocity probes; high frequency acoustic sounding: and Doppler acoustic current meter map ping. In addition, deployment of surface (and perhaps subsurface) drafters is planned, with CODAR measurements of surface velocity on each side of the ice margin. Tracer studies, which have recently been used to identify reidence times of subsurface water north of Fram Strait (Ostland et al., 1982) will be estended to the MIX.

In high lantiade biological systems, the ice edge region has higher levels of primary productivity than surrounding waters. Alexando



(1981) shows that over a third of the total primary productivity in the southeast Bering Sea comes in the single month of May, coinciding with the ice edge bloom. Associated with the bloom is a concentration of marine mainingle and birds at the ice edge, with some species adapted specifically to the ice-edge habitat. There are several competing hypotheses for the presence of the bloom, among them: (a) a benevolent environment furnished by a shallow, high-nutrient, mixed layer stabilized by melt water; and (b), increased nutrient levels associated with ice-edge upwelling. Recent work describing the halocline of the Arctic Ocean (e.g., Aagaard et. al., 1981) has émphasized the role of the broad Arctic shelves in maintaining the cold, saline layer of water that separates the relatively fresh Arctic mixed layer from underlying Atlantic water. Presumably, modified shelf water upwelled by processes at the ice edge could supply the needed elevated nutrient levels. If such up-welling is intermittent, the biological signal from each event may provide a 'memory' that is lacking in measurements of the physical

properties alone. Biological measurements in MIZEX will include phytoplankton biomass, phytoplankton species, nutrients, zooplankton biomass and diversity, and a variety of chemical compo-

#### Acoustics

The acoustic climate of the MIZ is complex. Ice itself is noisy in the region where surface wave energy is attenuated by jostling and fracturing of ice floes. Ambient levels are highest at the ice edge but fall off faster in the iceward direction, an effect attributed by Diachok (see Andersen et. al., 1980) to much higher reflection losses at the ice-water interface compared with the open sea surface.

The sound-speed profile is subject to large variations caused by frontal and eddy structure in the MIZ; these variations degrade horizontal coherence of acoustic wave (ronts and therefore the performance of directional acoustic arrays. Since acoustic tomography is potentially an important tool for measuring

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Cover. LANDSAT image of the sea-ice edge in the Greenland Sea. See The Oceanography Report, this issue. The Greenwich Meridian runs north from the oottom right corner of the image at about  $\delta 0^{\circ}$  to the left of vertical. The eddy-like eature centered near 79°40'N, 3°É, is oughly 90 km across. To the east of the 3°E meridian, warm surface water is ap-parently advected into the ice pack, while o the west, ice and cold water are swept toward open water. Eddies along the marginal ice zone are not uncommon in satel-lite imagery. However, the feature shown here is notable in that it appears to coincide with the bathymetric depression known as the Molloy Deep, (Photo courtesy of N. Untersteiner.)

eddy structure in the MIZ and because synoptic ice-roughness mapping is possible by acoustic backscatter techniques, it is important to determine variability and predictability of sound-speed structure.

Acoustic measurements in M1ZEX will include fixed and free drifting sonobuov arrays, ambient noise including directional information, a tomography experiment, plus seismic reflection and refraction experiments.

#### Modeling

Credible models of MIZ processes across the whole range of disciplines is a major goal in the MIZEX effort. A partial list includes: sea-ice radiation, thermodynamics, ridging, breaking, and rheology; aunospheric and oceanic boundary layers; eddy generation; fromogenesis and maintenance of fronts: quasisteady, mesoscale circulations in atmophere and ocean; fine structure and crossfrontal mixing; biological processes; internal waves; sound path and acoustic tomography; and many others.

In addition to their role as end products, models will be used prior to the experiment and in the field to optimize sampling strate-

### Organization and Planned Field

The experiment's basic organizational body, the MIZEX Science Group, consists of seven 'Discipline Chairmen' and nine 'National Coordinators' assisted by executive and logistics managers. The Science Group is responsible for determining overall scientific directions and for serving as liaison between scientists and national advisory and funding agencies. Two project offices and a logistics office have been established, publication of a newsletter has commenced, and a MIZEX Bulletin for presentation and discussion of

scientific matters is planned. The MIZEX 83 field project is scheduled for June—July 1988, beginning in the Green-land Sea morth of Svalbard (the precise location will depend on ice conditions). The icestrengthened research vessel Polachjorn will spend about 6 weeks on site. Innctioning first as a drifting ice station and then performing measurements in the region just seaward of the ice edge. She will be joined for about ren days by the icebreaker Palaistern for cooperative work in and near the MIZ. The Norwegian Polar Institute vessel Lance will also perform cooperative measuring programs in the vicinity. A number of fixed-wing aircraft from the United States, Canada, France, Denmark, and Norway will carry out remote sensing missions, and two helicopters will aid scientists in deployment and sampling opera-

MIZEX 84 is a much larger project, with five vessels and numerous aircraft and satellite platforms on hand for most of the 6-week field program in June-August 1984. One ship will serve as a drifting station within the ice pack for the entire experiment. Johannessen, Hibler, et. al. (in press) describe the scientific plan in detail.

Experience gained during MIZEX 83 will be used to design the 1984 experiment. Fol-lowing 2 or 3 years of data assimilation, there will be additional summer and winter experiments in the Greenland Sea.

Operational planning for MIZEX 84 is under way and will be completed at a meeting in Bremerhaven, Federal Republic of Germany, in November 1983. Discipline workshops will be held this spring to encourage input to the planning process from all interested sci-entists. Specific plans or suggestions should be discussed as soon as possible with the discipline chairmen or national coordinators, whose names and addresses and information on administrative matters may be obtained from Dean Horn, MIZEX Executive Officer. Arctic Programs Code 425AR, Office of Naval Research, 800 N. Quincy Street, Arling-

ton, VA 22217 (telephone: 202-696-4118).
The major U.S. sponsor of MIZEX is the Office of Naval Research with support from the National Science Foundation and the National Aeronautics and Space Admin Other sponsors include: the German Polar Institute, the Norwegian Polar Institute, Bedford Institute of Oceanography, the National Environmental Research Council of Canada, the Canadian Center for Remote Sensing, and the British Meteorological Office.

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Miles McPhee is with the Department of Oceanography, Naval Postgraduate School, Monterey, California,

#### News & Announcements

### Mysteries of **Bottom Water**

Ocean bottom water has historically represented a constant physical entity to most geophysicists. The ocean floor has long been nodeled as a classic isothermal, semi-infinite surface in geophysical calculations. Peter Rhines of Woods Hole Oceanographic Institution recently said about the subject of bottom water. We've all been trained to imagine that the deep ocean is steady. . . . It's not so much a belief, but a practice that became a way of teaching' (Science, November 12,

It is now becoming well known that, over housands of years, bottom water is not as stable as once thought. Large bodies of cold water are not really stable over even a decade. The large bodies move, the water itself is renewed, and as a result, the temperature and salinity of ocean bottom water changes regularly. New data point to a less than steady state condition for the water at the

It has always been assumed, and recently documented, that the deep sea communicates chemically and thermally with surface water. The surface water is mixed by current action and weather effects also can be translated by deep ocean circulation patterns. A rather important concept that now has become suspect, lowever, was that bottom water remained unchanged in spite of being replaced regularly. If the temperature is not constant in time, an important boundary condition for many geo-physical models is violated. The heat-flow ector can be affected and thus the thermal history of the interface must be modeled accurately. The new studies of deep ocean water could offer the possibility of constructing such a model.

. Kerr recently dis lantic data of the Transit Tracers in the Ocean (TTO) program, which were presented at the Ewing Symposium in October 1982 and a recent analysis of temperature and salinity observations along 36°N and 24°N latitudes. He said, 'This water was definitely different, which ran counter to the assump of the past 100 years of oceanography. This first detection of changes in the presumably immutable deep sea should aid the understanding of how the ocean manages to renew the water of even its deepest recesses. (Science, Nov. 12, 1982).

The studies being done can continuously be updated and can make reference to the

surveys made during the International Geo-physical Year (IGY) in 1958. The TTO program is a broad study to track the depth penetration of products of nuclear fallout, aerosol propellants, and the like in the oceans. Cemperature and salinity data obtained dur ing TTO cruises in the North Atlantic indicated that all water deeper than a few hundred meters north of 50°N latitude and south of Iceland has become a few parts per thousand less saline, and a few tenths of a degree colder, These data are samples of water that originates from the Laborador, Greenland, and Norwegian Seas and enters into the deep The survey along 36°N and 24°N followed the tracks of IGY surveys. The water at depths between 500 and 3000 m has become warmer by tenths of a degree Celsius. But above 500 m and deeper than 3000 m, extending to the ocean floor, the water was observed to be colder. How these changes might be related to those found in the North Atlan-

tic is not known. The changes observed are small relative to changes that drive ocean circulation. Nonetheless their magnitude must be known and their trends plotted accurately in time. Potentially also there could be a great deal to learn from these findings about the interaction between the atmosphere and the deep ocean.

#### Laser Sounding

Hydrographic surveying along the coastline must be done frequently because ocean bottom topography is under constant change. In a recent discussion in Naval Research News, M. B. White of the Office of Naval Research compared the traditional shipboard acoustic sounding method with the new Hydrographic Airborne Laser Sounder (HALS) being developed for the Navy and the National Ocean Survey. The shipboard system can be tlescribed by two words: slow, costly. According to a recent summary of White's discussion (Lasers & Applications, December 1982), the Defense Mapping Agency, which produces most civilian and military charts in the United States, now has a 200 ship-year backlog. The new HALS system will be 6 times less expensive to operate and 100 times faster. The questions remaining now are related to the type of airborne laser system that can pertorm the task, in a field of rapidly changing technology.

Sounding the bottom along coasdines can be done efficiently by a small, fixed wing aircraft carrying a state-of-the-art laser system that weighs about 600 kg. As an aircraft flies along an electronically positioned grid system, a laser emits pulses in the visible light region. The pulses are reflected both from the ocean surface and hottom, the difference being the slant depth. The time delays of the two reflected pulses must be measured with extraordinary precision. To achieve a hydrographic depth accuracy of ± 30 cm the temporal laser pulse width must be on the order of about a nanosecond. For civilian requirements a repetition rate of approximately 400 Hz is acceptable. There are several categories of laser-solid state, metal-vapor, and gas types-that can meet the requirements. The types described by White include solid state green, copper-vapor, eximer, and UV-

The lasers are new, and the techniques to make them perform are being updated regularly. For example, the solid-state neodymium-doped yurium aluminum garnet (Nd: YAG) laser normally entits a continuous, rather than pulsed, beam in the near infrared region. For hydrographic sounding the frequency of the output is doubled, the cavity is Q-switched to emit pulses, and the pulse is narrowed by a cavity dumper. Other solid state lasers now being tested can be tuned to emit over a range of wavelengths.

Whether of the solid state or (for higher repetition rates) gas medium type, the new lasers employ mode-locking principals. These systems employ state-of-the-art techniques such as cavity dumping, tunable dye laser in-termediate stages, and other methods to shape the pulses to a nanosecond or shorter width. For example a high-Q resonant cavity is placed in the system, and pulses are stored until a sufficient peak intensity is achieved. Fast "dumping" or release systems are used to extract very short pulses.

The color ranges required for hydrograph-

c purposes are in the blue-green (deep ocean) or longer wavelength (shallow waters)
spectrum. At green to yellow-green wavelengths the clouds algae-laden waters are relatively clear. Of course, tunable lasers are used, but there are a number of other laserthe vicinity of 500 nm. For example so-called wavelength conversion methods such as employing successive Raman-effect upshifts or downshifts can be efficient for gas laser sys-

The new systems will begin to be operative in the mid 1980's. A new variety of lasers are to become available at that time for an instant upgrade.—PMB

#### Ocean Data Tapes

Magnetic tape copies of the two data sets used to prepare the Southern Ocean Allas (Eas, August 3, 1982, p. 595) are available from the National Oceanographic Data Center. (NODC).

The allas data set is a screened and edited set of hydrographic station data that includes 6,318 stations. The grid point data set was produced by interpolating the hydrographic data to the points of a circumpolar grid system between 30°S and 80°S with 47 standard levels in the vertical direction.

Data tapes cost \$110 for each set: For additional information, contact NODC, NOAA/ NESDIS E/OC21, 2001 Wisconsin Avenue, N.W., Washington, DC 20255 (telephone: 202-684-7690),

Date	Time, (GMT)	Magnitude	Latitude	Longitude	Depth of Focus	Region
Jan. 8	1121	6.5 m <sub>b</sub>	15.24°S	173.40°W	shallow	Tonga Islands
Jan. 17	1241	7.0M <sub>s</sub>	38.09°N	20.19°E	9 km	Ionian Sea
Jan. 24	0818	6.7A1 <sub>s</sub>	16.28°N	94.98°W	58 km	southeastern Mexic
Jan. 24	2309	6.5A1 <sub>s</sub>	13.00°N	93.04°E	shallow	Andaman Islands

Information contacts: National Earthquake Information Service, U.S. Geological Survey, Stop 967, Denver Federal Center, Box 25046,

#### **Meteoritic Events**

Meteorite fall: Tennessee, USA, January

Fireballs: Germany (2), Poland, Colorado, Oregon (2), Washington.

Meteorite fall: Maryville, Tennessee, USA (35.80°N, 84.01°W). A brilliant fireball was observed in the Knoxville, Tennessee, area early January 28. On January 29, a resident of Maryville, 30 km S of Knoxville, found a meteorite in a small, recently-formed crater. The equidimensional and roughly softball-sized metebrile had a mass of 1,442 kg, a smooth ablation surface, and a fusion crust less than I mm thick. Lawrence Taylor reported that classification work was in progress, but the meteorite appeared to be an rdinary chondrite. A fragment of roughly 150 g was sent to Battelle Northwest Laboratory in Richland, Washington, for counting of short-lived, low-level radioactivity. No other pieces of this meteorite are known to have been recovered.

Information contacts: Lawrence Taylor, Department of Geological Sciences, University of Tennessee, Knoxville, TN 37916 USA.

### Methane Ocean On Titan?

There was an impressive list of names on a recent scientific communication that argues for the existence on Than of an ocean of liquid methane (CH<sub>4</sub>) perhaps several hundred meters deep, C. Sagan and S. Dermott with helpful comments by S. Oter, S. Ostro, S. Peale, G. Yoder, W. Thompson, S. Squyres, G. Pettengill, P. Gierasch, and B. Khare speculate that such a methanic ocean, with its Saturnian tides and its tholinian floor, should

exist all over Titan's surface; it should unless. they conclude, there is the 'distracting coincidence [that] ... the position of the surface of Titan [is] ... near the liquidus in the CH4 phase diagram [and, consequently, there is] almost no methane ocean at all' (Nature, *300*, 731, 1982).

We know very little about Titan and its surface; the way of checking into Sagan and Dermott's ideas appears to rest on the interpretation of radar reflectivity data. Preliminary attempts to obtain radar data were made in 1979 with the 305-m Arecibo telescope, but only broad limits resulted. The next opportunity for a measurement at Arecibo comes in the 1990's. Of course, the ideal circumstance would be to send spacecraft equipped with a radar reflectometer for a Ti-

One of the reasons that calculations of the type done by Sagan et al. can yield results of such wide variance—a deep methane ocean or no ocean at all—is that the astronomical constants for Titan upon which the geophysical calculations are based are not well enough determined. They are, however, many orders of magnitude better determined than they were a few years ago, before the United States space exploration program. The values are good enough to work with now, which could not be said even 10 years ago.

The factors about Titan's physical figure are not at all related to the organic, possibly biochemical, arguments often associated with the first author of the paper, Carl Sagan. One cannot get away from the organic nature of the main constituent, methane, which with ammonia and water is believed to compose Titan's icy mantle; Titan probably has a rigid, rocky core, however. There is included in the note a suggestion of Sagan's tholin ideas, which describe the interaction of UV light and charged particles with Titan's atmosphere to produce a class of dark organic solids that, he argues, coat the land (if there is any) and the submarine surfaces. But, that Titan probably is composed of pure, virgin,

abiogenic matter seems to hold. The problems of doing geophysical calculations on 11 tan stem from factors such as the nature of Titan's orbit and whether or not Titan's inte rior has relaxed in its lifetime to a state of near-hydrostatic equilibrium. Litan has a comparatively high orbital eccentricity (c. 0.0289), and it is not known yet whether I rtan is in synchronous rotation.

Recping in mind that Titan's density distribution (the mean density of Titan is 1.88 + 0.01 g cm<sup>-3</sup>, B. Smith et al., Science 215, 504, 1982) is not known, and that various factors such as Titan's solid-body and fluid-occur (it there is one) rigidities are also unknown, Sagan et al. describe the difficulties that arise from known values of Titan's eccentricity. Ittan's orbit is far from being circular, and the time constant (l') for the decay of an everytric orbit used by Sagan et al. is

 $\Gamma = 2/21 \ (M_s/M_s) \ (a/R)^5 \ Q/nK_2$ 

where  $M_t$  and  $M_t$  are the masses of litan and Saturn; a is the semimajor axis of Titan's orbit; R its radius; and n,  $K_2$  and Q the critical unknowns: the mean motion, the Love number, and the specific dissipation function, respectively. To have a decay time of less than 4.6 billion years (presumably the age of the solar system), Q it turns out, must be greater than 200, which would be consistent with the existence of a deep ocean completely covering Titan's surface.

Sagan et al. note that Titan's rotation is such that one sector of its surface is directed toward the empty focus of its orbit. The tidal bulge is directed toward Saturn, and thus the tide oscillates across the surface. They argue that the energy losses due to these oscillations should tend to dampen the orbital eccentricity; as they state it, 'the present, comparatively gh value of e is difficult to understand.

Why argue for a methane ocean on Titan? Sagan and Dermott note that the surface condinons (T = 95 K, P = 1.6 bar) on Tium are suitable thermodynamically to stabilize liquid methane. Data from the Voyager 1 spacecraft suggest that methane abundance in Titan's lower atmosphere is better than 0.19 of saturation, and by comparison with the figures on the earth's H<sub>2</sub>O atmospheric saturation, methane should begin to condense out (rain). Comparison with the earth's ratio of water in the atmosphere to water in the oceans (a factor of 104) suggests that Titan's occaus, if they exist, are deeper than 100 m. The present high eccentricity of Titan's orbit around Saturn would be consistent with a methane ocean deeper than 400 m.—PMB

## **Meteorite Find Yields Carbon**

In the new cache of mercorites recently found in Amarchea, 28 of the 31 disosered are carbonaceous choudries, a type of meeorte rate for its earlien content. According to the National Science Foundation (NSF), the meteorites were discovered at the Pecora Escat pinent, the southernmost exposure of rocks of the Pensacola Mountains, Anaroi conditions keep the meteorites nearly free of terrestral organic contamination, making the meteorites, extraterrestrial ordanic tollipounds especially valuable to researchers.

According to NSF, the discoverers termed the recent find his good as the 1977 discoery at Allan Hills, in Victoria Land, of the largest meteorite ever found in Antarcies one weighing 407 kg. In that year, only about 25 of the world-supply of 2000 meteories were carbonaccous chondrites.

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# **Books**

#### Advances in Geology of the Porphyry Copper **Deposits: Southwestern** North America

S. R. Titley (Ed.), The University of Arizona Press, Tucson, xiv + 560 pp., 1982, \$35.00

Reviewed by Stephen E. Kesler

This book summarizes recent advances in information on the porphyry copper deposits of southwestern North America. It is a sequel to an earlier summary volume published by the same group in 1966. The new volume is indispensable for anyone interested in copper deposits and a valuable reference for those working in fields ranging from the petrology of silicic igneous rocks to the tectonic evolution of western North America. The volume is particularly significant because porphyry coppers are by far the most important class of deposits in terms of global copper reserves and, most importantly, because southwestern North America contains an unusually large number and variety of these deposits.

In using this volume it is important to keep in mind that 16 of the 27 chapters were written largely or entirely by geologists from industry whose first responsibility is to exploration and production rather than to research and publication. It is no small task for these geologists to obtain management permission to write papers about their deposits or, in fact, to find time to write. It is an even tougher job to coordinate a volume such as this with contributions from academia, industry, and government, and we can be grateful to editor Spencer Titley for his commitment to

this project. The volume is divided into two parts. The first part contains 13 articles on selected topics in porphyry copper geology including general studies of the grade, tonnage, and economics of worldwide porphyry copper deposits as well as more specific, southwestern North America-oriented papers on the genlogic setting of the deposits; their thermal evolution, fracture, and dike patterns; alteration mineralogy, chemistry, character, and evolution; associated skarn alteration and mineralization; leached cappings; and geochemical exploration techniques. This section also includes more specific papers on primary metal dispersion haloes around the Kalamazoo deposit, the geochemistry of sulfur and copper at the Ray deposit, and the petrology of the Ray igenous rocks. Much, though not all, of the information in this section has appeared in print previously, so the value of hese papers must lie in their success in drawing new and useful conclusions. Particular success along this line is seen in the chapters on alteration mineralogy and on leached cappings. The second section includes 13 papers on deposits that had not been described previously in any detail or for which significant new data had become available within the last decade. The papers in this section vary widely in quality, but all provide at least a basic

geologic framework for the deposits. Particularly commendable in this section are the attempts that have been made to provide information on the relation between copper and molybdenum grades and related geologic features. Comprehensive descriptions such as this are necessary if we are to develop truly

realistic genetic models for these deposits. Considered in its geologic and editorial context, this volume cannot be criticized to any real extent. Its broadest shortcoming, the failure to propose genetic models for the processes and deposits that are discussed, is actually a realistic reflection of the extreme complexity of these deposits and our still limited research progress on them. The lack of a chapter on geophysical exploration methods for these deposits is in part made up for by information in the recently published 75th anniversary volume of the Society of Economic Geologists. Typographic and illustra-tion errors are remarkably scarce.

This volume will no doubt remain a valuable source of data for students of late magmatic mineralizing processes for many years to come and, it is hoped, a starting point for a third, and final (?) summary volume near the end of the next decade.

Stephen E. Kesler is with the Department of Geological Sciences, University of Michigan, Ann

## New Publications

Items listed in New Publications can be ordered directly from the publisher; they are not available through AGU.

Astronomy and Astrophysics Abstracts, vol. 31, Literature 1982, Part 1, S. Bohme, W. Fricke, H. Hefele, I. Heinrich, W. Hofmann, D. Krahn, V. R. Matas, L. D. Schmadel, G. Zech (eds.), Springer-Verlag, New York,

Cartographic Drawing with Computers, P. Yueli, Computer Applications Special Issue, vol. 8. Department of Geography, University of Nottingham, Nottingham, U.K., viii + 137 pp., 1982, \$12.

Chemistry of the Unpolluted and Polluted Troposphere, H. W. Georgii and W. Jaeschke (eds.), Proceedings of the NATO Advanced Study Institute held on the Island of Corfu, Greece, September 28-October 10, 1981, D. Reidel, Boston, ix + 509 pp., 1982, \$63,00.

Earthfire: The Eruption of Mount St. Helens, C. Rosenfeld and R. Cooke, MIT Press, Cambridge, Mass., vix + 155 pp., 1982, \$25.00. Electromagnetic Sounding Interpretation Duta Over Three-Layer Earth, R. K. Verma, IFI/ Plenum, New York, vol. 1, x + 338 pp.; vol. 2, v + 546 pp., 1982, \$165 each.

Fertilization of Dryland and Irrigated Soils, J Hagin and B. Tucker, Advanced Series in Agricultural Sciences, vol. 12, Springer-Ver-

lag, New York, viii + 188 pp., \$39.50. Fortran Program for the Computation of Gravi-metric Quantities from High Degree Spherical Harmonic Expansions, R. H. Rapp, Report 334, Ohio State University Department of Geodetic Science and Surveying, Colum-

bus, iv + 28 pp., 1982.

Geological Evolution of the Earth During the Precambrian, L. J. Salop, translated by V. P. Grudina, Springer-Verlag, New York, xii + 459 pp., 1983, \$65.80.

Geology of Offshore Ireland and West Britain, D. Naylor and P. Sannon, Graham and Trotman, London, 1982.

Global Atlas of Sea Surface Heights Based on the Adjusted Seasat Altimeter Data, R. H. Rapp, Report 33, Ohio State University Department of Geodetic Science and Surveying Columbus, v + 63 pp., 1982. High-Pressure Research in Geophysics, S. Aki-

moto and M. H. Manghnani (eds.), Advances in Earth and Planetary Sciences, vol. 12, D. Reidel, Boston, xiv + 632 pp., 1982.

The price of Evaporation Into the Atmosphere: Theory, History, and Applications, by W. Brut-sacri, D. Reidel, Hingham, Mass., was incorrectly listed in Eas, Dec. 21, 1982, p. 1223; the correct price is \$34.95. 

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The person obtaining the appointment would be responsible for a portion of the planning and execution of the field study, much of the subsequent data analysis and interpretation and teaching of

responsible for a portion of the planning and execution of the field study, much of the subsequent data analysis and interpretation, and teaching of one graduate level course in physical occanography each year. The successful applicant must have received the Ph.D. in physical occanography or a closely related field by the starting date of his appointment. Preference will be given to applicants with direct experience in field observations.

To apply send a complete resume and the names of three references to Professor R. W. Garvine, College of Marine Studies, University of Delaware, Newark, DE 19711. (Telephonet (302) 738-2169).

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Applicants should send a resume and the names of three references to: Dr. Thomas C. Hinkson, Head, Department of Physical Sciences, P.O. Box T-69, Tarleton State University, Stephenville, Texas 76402. Telephone 817/968-9143.

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Postdoctoral Position/Selsmology. Postdoctoral support in seismology is tentatively available for up to a 24-month period. Seeking a recent Ph.D. with interest in regional seismic wave/surface wave propagation. Applications should be sent to: Dr. Robert G. Hermann, Department of Earth & Atmospheric Sciences, St. Louis University, Box 8099, St. Louis, MO 69166, 314-688-3120.

St. Louis University is an affirmative action/equal

Atmospheric Scientist-Programmer/University of Nevada System. The Desert Research Institute has an opening for an Atmospheric Scientist-Program-nier within the Atmospheric Sciences Center. The

O 65156, 314-658-3120.

STUDENT OPPORTUNITIES

Variable stipends Areas of geophysical research at Wyoning: Reflection seismology Gravity and magnetic potential field studies Physical properties Paleonagnetism and rock magnetism Crudal structure and magnetism Pateomagnesses

Crustal structure and magners of Fectoric modeling Seismic data processing Contact: Dr. Kevin P. Futbing Dept. of Geology/Georghysics University of Woming PO Box 5000 Univ. Station Usernam Acc 80071 Laramie, WY 82071 307/766-4379.

Gradunte Fellowships In Goastal and Continental Shelf Sedimentation. The Geology Department of Dalhousic University invites applications for graduate fellowships leading to M.Sc. and Ph.D. degrees with specialization in the field of coastal and considerated shelf scalimentation. Potential research area include shoreface and sediment processes, instrumentation for sediment transport studies and construction of coastal Laties mades. Opportunities exist to take part in the upcoming Canadian Coastal Sediment Study and to gain scientific cruise experience on research vessels from Bedford Institute of Oceanography. Awards cover a calendar year sipend and are valued, after fees are deducted, between \$5500-\$8000. For further information or application please write: plication please write:

> Dr. R. Boyd Geology Department Dalhousie University Halifax, Nova Scotia GANADA B311 315.

Graduate Research Assistantships/Cold Regions Science & Engineering. Theoret School of Engi-neering at Darmouth College and the US Army Cold Regions Research & Engineering Laboratory invite applications from students interested in ME, MS, Ph.D. & DF programs with specialies in the cold regions. Potential research areas include: geophysics of snow, ice & trozen ground; hydraulia and hydrology in cold regions, polar marine engi-teering; and materials science of ice and other fro-

an opening for an Atmospheric Scientist-Programmer within the Atmospheric Sciences Center. The individual will take part in the processing, analysis, and interpretation of aircraft cloud physics data and data collected with radar, radiometer, and lidar remote sensing instruments in cloud physics and weather modification research projects. Initial emphasis will be on developing computer-generated-graphics data display capabilities at DRI. Emphasis will then shift to data analysis and interpretation and publication of results. Opportunities exist for developing own research projects. Desirable qualifications include a Ph.D. in atmospheric sciences with 2 to 5 years experience in computer-assisted aircraft ant/for remote sensing data display and analysis. Strong candidates with the M.S. degree in atmospheric sciences or related fields of physical science with extensive relevant experience will also be considered and are encouraged to apply. The salary will be attractive and is negotiable, full benefit package is included. Send letter of application, a complete resume stating particulars of education and experience, and names, addresses, and telephone numbers of three individuals who can comment knowledgeably about your capabilities, postmarked by April 1, 1983, to: Mrs. Harrison, Personnel Office, Desert Research Institute, University of Nevadia System, P.O. Box 60220, Reno, Nevad cering: and maces and community and physics, undergraduate majors in engineering, physics, and geophysics are encouraged to apply. For admission requirements and more detailed information

The Dean of Thayer School of Engineering Dartmouth College Hanover, N11 03755.

SERVICES, SUPPLIES, COURSES, AND ANNOUNCEMEN IS

#### **INSTITUTE ON FLOODS**

June 27-July 1, 1983 Colorado State University Fort Collins, CO

Special written lecture notes for prediction estination and forecasting of floods. Well known meth empirical methods will be described.

R. Clark J. Sallas

V. Yevjevich Fee: \$600.00 Limited funds available from UNESCO for partial uition sponsorship for particity ents from develops

H. Shan

countries. Carriyn Frye Institute of Conferences Colorado State University Fort Colling, CO 80523

# She thinks impatience is a virtue.

# AGU

### Gelhar Receives Horton Award



#### Citation

The field of subsurface hydrology was pertups the last area of hydrology to abandon strict determinism and to incorporate into its analysis the ample uncertainty arising from the arricture and properties of the medium. Recent years have seen an explosion of activity in this area, however, made possible in large part by the pioneering contributions of this year's Robert E. Horton Award winner.

His early papers on the spatial variability of aquifer parameters established a general ramework for the treatment of random hydrautic conductivity variations in un aquifer by means of stochastic differential equations. This provided the basis for his important later work on the stochastic theory of macrodispersion in nonuniform porous media. The impact of his contributions is evident from the large number of recent symposis and publications devoted to the slochastic description of groundwater flow and from the fact that his work is referred to extensively in the

He did all his formal academic work at the 186

University of Wisconsin and first joined the MIT faculty in 1964. He left MIT for the New Mexico Institute of Mining and Tech-nology in 1973 and rejoined the MIT faculty this past September. He is a personal friend of long standing and I can think of no one to whom I would rather present the 1982 Robert E. Horton Award than Lynn W. Gelhar.

. P. S. Eagleson

It is a pleasure to receive this award not only as an indication of individual achievement but also as recognition that stochastic subsurface hydrology hus become well estab-lished as a legitimate area of research. This has not always been the case. Ten years ago when I first began to work in this area one of the leading groundwater researchers strongly advised me that the stochastic approach was unnecessary because groundwater flow is completely described by deterministic equa-

Acceptance

ions. Needless to say I did not heed that ad-I want to acknowledge the contributions of colleagues at New Mexico Tech and MIT who have worked with me and had an important influence on my thinking in this area. Also, I have been fortunate to have had a succession of sharp graduate students who have worked with me in this area and have benefited from some stimulating competitio

from individuals like Gedeon Dagan: I would like to ofter some of my perspec-tive on the area of stochastic subsurface hy-

drology. To me this is more than a question of probabilistic theory or computational methodology. In my view the motivation for a stochastic approach presents itself rather strongly in field observations of the natural variability of properties such as hydraulic conductivity. The key element of the stochastic approach is the coupling of that natural variability with well-established physics which is based on controlled laboratory experiments. The goal is a quantitative description of the controlling, large-scale processes which determine field-scale behavior. The stochastic approach expresses that large-scale behavior in terms of the expected value, and second moment analysis gives a measure of the variability of the prediction about the mean.

Graduate Research Assistantships in Earthquake and Exploration Seismology/University of Ransas. The computer acquisition of digital seismolograms for a 20 + station seismic network covering the southern end of the Central North American Rift System and the development of rechniques for Very High Frequency (500-1000 Hz) reflection seismology provide excellent opportunities for graduate study at the M.S. or Ph.D. level. For further information and/or application, please write:

Dr. George H. Rothe, Chairman Geophysics Program
Department of Geology
University of Kansas
Lawrence, Kansas 66045
(913) 864-4974.

The field of stochastic subsurface hydrology has benefited from a diversity of methodologies; comparisons of results have made it possible to develop confidence in the reliability of the various methods. For example, in the very important case of solute transport three distinctly different methods of analysis by independent researchers (Dagan, 1982; Gelhar and Axness, 1983; Winter, 1982) all have produced essentially the same result for the macroscopic dispersion coefficient. The results in this case have important practical implications. First of all, the theory shows that the mean behavior, as reflected in the macrodispersion coefficient, is strongly influenced by the variance of the logarithm of hydraulic conductivity. This is in contrast to the head prediction problem where mean behavior is only weakly dependent on log-conductivity variance. Second, near the source, the mean concentration field is not described by the

classical convertive dispersion equation; the

dispersion coefficients depend on displace ment distance, and higher order derivatives produce skewed concentration distributions. Also, the concentration variance is very large near the source. When we look carefully at field observations, these same features are ap-This discussion of the solute transport

chastic subsurface hydrology. Our methods have developed to the stage that we can use the results with some confidence to look care fully at large scale field behavior. In doing se we discover some nonclassical behavior which seems to be reflected in field observations. The results of the stochastic analyses of sub surface transport processes point to the need for a more balanced approach which integrates geologic information, field experime ation, statistical analysis and numerical sim lations. In my view that approach is essential to quantitative understanding of the field scale phenomena which are important in problems of resource development and entitle ronmental protection in the aqueous under

#### References

Dagan, G., Stochastic modeling of groundw ter flow by unconditional and conprobabilities, 2, The solute transport, Wale Resour. Res., 18, 835-848, 1982.

Gelhar, L. W., and Axness, C. L., Three-dimensional stochastic analysis of macrodispersion in aquifers, Water Resour. Res., 19, n press, 1983.

Winter, C. L., Asymptotic properties of mass. transport in random porous media, Ph.D. dissertation, Univ. of Ariz., Tucson, 1982.

# <u>Meetings</u>

#### Announcements

#### Atmospheric **Contaminants**

The deadline for submission of abstracts for the World Meteorological Organization Technical Conference on Observation and Measurement of Atmospheric Contaminant (TECOMAC) is March 31, 1983. The niceting will be held October 17-21, 1983, in Vienna, Austria. A major objective of the meeting is to establish the state of present knowledge of man-induced and natural chemical and physical atmospheric parameters and of how they affect climate and the environment.

The organizing committee will select papers on topics that include chemical climatology and its evolution; significance of air chemistry observations for understanding and predicting the state of the environment and climate variations; observation and measurement of long-lived and reactive gases, aerosols, turbidity, dry deposition, and chemical constituents in precipitation and organic contaminants; instruments, analytical techniques (including isotope and nuclear), standardization, quality assurance, and data evaluation techniques; and interaction of atmospheric constituents with adjacent environmental media

Abstracts may be forwarded to the WMO Secretariat, Attention: C/ENV, Case postale no. 5, CH-1211 Geneva 20, Switzerland. They must be written in English and should not exceed 200 words.

The conference is cosponsored by the International Atomic Energy Agency, UNEP. and the Austrian Zentralanstalt für Meteoro logie und Geophysik.

#### Environmental Satellites

A workshop on the uses of environmental satellites will be held March 21–23, 1983, in Santa Barbara, California. Included in the topics to be discussed by panelists from the United States, Canada, and France will be the mission of the new polar-orbiting environmental satellite, NOAA-E, and its sensors, which include first-time instruments on a L'S satellite that are useful in global search and rescue operations. The launch of the RCA-built satellite from Vandenberg Air Force Base in California is scheduled for March 28.

For additional information on the work-shop contact Pain Rainaglia, MS 501, RCA Astro-Electronics, P.O. Box 800, Princeton NJ 08540 (telephone: 609-426-2713). The workshop is sponsored by NOAA's National Environmental Satellite, Data, and Information Service and by RCA.

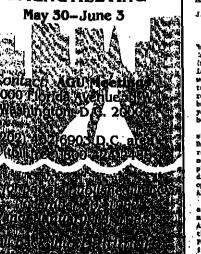
## Digital Signals

The Acoustics, Speech, and Signal Processing (ASSP) Society of the Institute of Electrical and Electronics Engineers will sponsor the Third ASSP Workshop on Multidimensional Digital Signal Processing in Lake Tahoe, Calif., October 19-21, 1983.

# Ahoy! March 9

Abstract Deadline 1983 AGU

Spring meeting May 30-June 3



Attendance is both by invitation and application. Those interested in participating should contact no later than July 1 the registration chairman, John Hulsmann, Grumman Acrospace Corporation, Bethpage, NY 11714 (telephone: 516-575-2054).

# Geophysical Year

#### New Listings

The complete Geophysical Year last appeared in the December 21, 1982, Eos. A boldface meeting title indicates sponsorship or cosponsorship by AGU.

March 21-23, 1985 Workshop on Uses of Environmental Satellites, Santa Barbara, Calif. Sponsors, NOAA National Environmental Satellite, Data, and Information Service and RCA. (Pain Ramaglia, MS 501, RCA Astro-Electronics, P.O. Box 800, Princeton, NJ 08540; telephone: 609-426-2713).

October 17-21, 1983 Technical Conference on Observation and Measurement of Atmospheric Contaminants, Vienna, Austria. Sponsors, World Meteorological Organization, International Atomic Energy Agency, UNEP, and the Austrian Zentralanstalt für Meteorologic und Geophysik. (WMO Secretariat, Attention: C/ENV, Case postale no. 5, CH-1211 Geneva 20, Switzerland.)

September 23-24, 1983 Models in Geomorphology, Buffalo, N. Y. (Michael Woldenberg, Department of Geography, State University of New York, Buffalo, NY 14260.)

January 23-27, 1984 Ocean Sciences Meeting, New Orleans, La. (Meetings, AGU, 2000 Florida Avenue N.W., Washing-

August 5-16, 1985 [AMAP/IAPSO ]oint Assembly, Honolulu, Hawaii, (Meetings, AGU, 2000 Florida Avenue, N.W., Washing-

September 17-21, 1985 AIPG Annual Meeting, St. Paul, Minn. Sponsor, American Institute of Professional Geologists. (Robert E. Prendergast, General Chairman, 1925 Oakcrest Avenue, Roseville, MN 55113; telephone: 612/636-7744.)

### Meeting Report

## **PNW Region Holds** Joint Meeting

The twenty-ninth AGU Pacific Northwest Regional Meeting was held September 15-16, in Fairbanks, Alaska. This was the first time that the meeting was held in Alaska, which, incidently, has the highest per capita AGU membership in the United States. The thirtythird meeting of the Alaska Science Conference (AAAS) was convened jointly (September 16-18) with the AGU meeting. Approximately 550 participants attended the AAAS portion and presented 220 papers; about 150 attended the AGU segment and presented 63 papers. Carl Benson chaired a joint plenary session on 'Geophysics of Alaska's South

Special acknowledgement must be given to Maggie Billington who handled the logistics for both meetings. The combined meeting enhanced both events and we anticipate a similar arrangement when Alaska hosts the

This meeting report was prepared by Thomas sity of Alaska, Fairbanks.

#### General Tectonics and Tectonophysics

Arctic-Alaska, a two-stage Displaced Terrage

J.F. Steenay (Pacific Geometrice Captre, Box 6000, Sidney, B.C., Canada VOS 1A0)

One of the oldest ideas for opening the Canada Yasin is the cotation of Alaska sway from Arcticianeds about a prox near the Mackania Belta. In support of the idea, the basin, formed in Latest Jurassic-serly Cretaceous ties, has weakly lineated suggestic anomalies that support or radiate from the Mackania Belta region. Also, restoring the rotated blook achieves a good bathymatric fit and, for late Valcovoic and younger pre-rift age rocks, a good geological fit between porthern Alaska and the Arctic Islands. The rotation hypothesis does not explain structural and matamorphic differences between Bevenian and older Palcovoic rocks across the restored boundary between Estal Island and northern Alaska. This reconstruction also places sajor std-Palcovoic sediment transport directions within adjacent tartense in opposition, northeasterly in a restored Arctic-Alaska, southeasterly in poles Canada. In this talk, the known geology of mid- and early Palcovoic yocks is compared cloug the sarging of the restored arit and the anomalous Arctic-Alaska certain is applained as a block that was displaced southwastered in mid- Palcovoic time by as such as 2000 be from its initial orogenic size to the north and asst of Ellessers Island.

Eccene Palsolatitudes for the Aleutian Islands

D. STONE (Geophysical Institute, University of Riaska, Fairbanks, Alaska 99701) M. HARBERT (Stanford University, Palo Alto, California 94305) T. YALLIER (U.S. Geol. Surv., 345 Hiddlefield Road, Menlo Park, California 94025) H. McLEAR (U.S. Geol. Surv., 345 Middlefield Road, Menlo Park, California 94025)

Paleomagnetic data from sets of samples of Late Eccene age from Amatignak, Umnak (Nikolski) and Amila Islands give mean paleo-latitudes south of their present latitudes, but with error bars permigsive of the latitude not having changed with respect to gengraphic coordinates. The rocks sempled all had clearly defined bedding planes taken to represent ancient horizontal. Samples from Amila Island were not oriented with respect to azimuth, hence only give information on the magnetic inclination which is of normal polarity. Data from Umnak Island and Amatignak Island show both normal and reversed polarities. Preliminary means corrected for Escianic tilt are:

D IK a H A Ø Paleo-A Amatignak 53 57 22 15 6 51 270 38 67 64 23 11 9 47 262 46

- 64 27 12 7 - - 46 I, declination and inclination of the magnetic vector, λ, θ, let. and long. of equivalent pole positions.

When these Aleutian data are compared with data from Cratonic N. America they indicate a porthward translation and a clockwise rotation of the rocks since their deposition. This is in accord with a late arrival of the terranes of S. Alaska, including the Aleutian Islands.

An Island Arc Gabbroic Complex in southern Ab.

1. R. BURNS (Goophysics Department, Stanford
University, Stanford, Ca., 9430;
G. S. PEESEL (A.D.G.G.S., Aachorse, Ak., 99501)
N. SLEEP (Goophysics Department, Stanford Univ.)

G. 8. PEESEL (A.D.G.G.S., Anchorse, Ak., 99501)
M. SLEEP (Geophysics Department, Stanford Univ.)
Geologic mapping and geophysical encember indicate the presence of a narrow, clongate belt (1000 km) of gabbroic and ultramafic rocks in ecurhern Alaska. Although the rocks are bounded by a major auture mose, the Border Esnages fault, and superficially appear to rescable an ophiculite, petrologic and compositional data clearly indicate that these rocks were not formed at a mid-ocean ridge or back-arc basin.

The Meichina gabbroic complex, the largest on-power to the belt, varies from 2 to 10 km in width, and crops out for 150 km in an anse-west trend. The layered gabbroic rocks are in fault contact to the north with the Tellewine Formation, an early juresait volunit are, and are fault bounded on the south by the Heilugh Complex, a late (?) Crotaceous subduction as lange. Data tled capping at 112400 and regional mapping at 113000 indicates that the gabbroic complex commists predominately of gabbrosories, but diorite, quartz diorite, and lesser ultramafit rocks accur locally. Specific features of Melchina gabbro which indicate a non-ophicalitic origin include a thick made and incomplex incomplex very minor cliving, locally abundant latermagnatic hornblands, and clone applied in trusions; gabbro-quartz diorite mignatices are perticularly common.

Comperison with data from the Marianus and theutian arcs suggest that the Melchina gabbroic complex represents part of the basel accumulation of an inland arc. A brief examination of ultramafic bodies within the same trend suggest that they come are not ophicalitic, but rather are pert of the taland arc floor. The most obvious volegaid equivalent, besed on location and K-Ar date, is that talkeatum Formation to the north. The salar-ence of this non-ophicalitic belt of rocks has depotent alaske.

#### Determination of Rock Hass Deformation Modulus in Closely Jointed Columbia River Basalt

O. C. LANIGAN (Baselt Meste Isolation Project, Rockwell Henford Operations, Richland, WA 99352) M. L. CRAMER (Same as Above) K. KIM (Same as Above)

R. KIM (Same as Above)

This paper describes the results obtained to date from a comprehensive laboratory and field investigation being conducted by the Basalt Maste Isolation Project (BMIP) of Rockwell Hanford Operations to determine the rock mass deformation characteristics of Columbia River basalts. The BMIP is in the process of assessing the suitability of the Columbia River basalts located in southeastern Washington as a potential site for a nuclear waste repository.

Understanding of the deformational response of a rock mass in a repository environment is of fundamental importance for repository design. The deformation modulus of basalt was measured by various methods including laboratory core tasts. All borabole Jacking tasts, and a flat Jack test conducted in a 2 m wide by 4.5 m deep horizontal slot in situ.

A comparison of tast results implies that the deformation modulus dermand with increasing specimen size in a similar fashion to the rock mass strength. Test results show deformation modulus values of 87, 40, and 20 GPs from laboratory tests of intact core, borshole

modulus values of 87, 40, and 20 MP from laboratory tests of intact care, borshole deformation measurements in a flat jack test, and borshole jacking tests, respectively, remperature did not appear to affect the modulus values significantly up to 100°C in both laboratory tests and in the flat jack

test.

A further field investigation which is currently in progress involves testing of a 2 x 2 x 2 m cube of basalt in a switterial leading configuration at temperatures up to 200°C and pressures up to 200°C. This test will provide data that will assist in establishing the size dependency of deformation properties of the basalt, which is critically needed for repository design studies.

### Constraints on Tectonic Models for the Columbia Plateau From the Age and Growth Rates of Yakies

5. P. REIDEL (Rockwell International, Richland, R. FECHT (Rockwell International, Richland, W. CROSS (Rockwell International, Richland, 99352)

The age of deformation and the rate of growth of Takima folds have been determined by studying the distribution and thickness variations of Columbia River basel, intercelated seddeents, and seprements that anticlinal ridges, synclinal basins and a westward tilting paleoslope are the main structural elements of the west and central Columbia Plateau. Thickness variations in the flows, as they cross these structural features, indicate that the anticlinal ridges and synclinal pasins began growing in Grande Ronde time (16.5-14.4 mybb) and continued to grow through the

Miocene. Suprabasalt sediments show similar variations, and indicate the structures continued to grow in the Pilocene and into the Quaternary. The rate of which these structures graw can be calculated by using flow thickness variations which essentially record the valler at the time of gruption. These calculations indicate deformation was greatest in Sranda Ronds time (>200 m/my) and decreased (~400 m/my) into the Hanapum (14.5-13.5 mybs) and Saddle Hountains time (13.5-10.5 cybs). Suprabasalt sediment thickness variations suggest uplift and subsidence Continued into the recent at this low rate.

rate.
The age and growth rate constrain tactonic models for the Columbia Plateau. These models must permit fold growth in restricted areas over at least 15.5 my and a decreasing rate of deformation with time.

AN APPLICATION OF NEAR PLELD STATES TILT PROM

J. F. Lewkowicz (Scone & Webster Engineering P.O. Box 2325 Boston, MA 02107

Experimental results show that it is funcible to measure slastic modeli in-situ using a burled tiltester to monitor ground tilt from a surface load. Potential applications for such a technique are the non-destructure evaluation a technique are the non-destructive oveluation of pavenest subgrades and the continuous somitoring of ground deformation during and after large construction projects. In the course of this investigation it begans names and the course of this investigation in the destruction between measuring horizontal and varieties are reviewed. The codification and application of the theoretical expressions to field measuraments is presented. The results are relevant in engineering altuations where this measurements are usually made in the near field, and to crustal deformation studies when carriers this staturements are compared to levaling data.

Mark Your Calendar, Now! Ocean Suerces

January 23-27, 1984 New Orleans, Louisiana

Meeting Cochairmen: John R. Apel, The Johns Hopkins University, Applied Physics Laboratory, and Richard T. Barber. Duke University, Marine Laboratory

To be placed on a special mailing list, write to Ocean Sciences Meeting. AGU, 2000 Florida Avenue, N.W., Washington, D.C. 20009. Call for papers to be published in Eos.

#### The Climatic Effects of Volcanic Dust and Aerosols in the Upper Atmosphere

Friday, March 18, 1983 8:30 a.m.-5:00 p.m. National Bureau of Standards Auditorium 25 Broadway, Boulder, Colo

Sponsored by the AGU Front Range Branch Cosponsored by the Denver/Boulder Chapter, American Meteorological Society

This symposium will bring together prominent researchers in the fields of climatology, meteorology, glaciology and volcanology to summa-rize the state of knowledge on this subject in an interdisciplinary forum at a level appropriate for a non-specialized, but scientifically literate audience. The meeting is open to the public.

Topics will include

 The history and causes of climatic variations • Explosive volcanism Atmospheric effects and observations
 Climatic and cultural consequences.

Contacts: Jules Friedman and Raymond Watts U.S. Geological Survey, P.O. Box 25025 Mail Stop 964, Denver, CO 80225 (303) 234-3676 (Friedman) or 234-3493 (Waita). For further information, see Eos Meetings Sec-

tion, February 15, 1983.

#### Geochemistry

### Gold Content of Rocks of the Patibishs Mining District, Alaska

#### D. B. HALKINS (Geology/Geophysics Program, University of Alaska, Jelrbanks, Alaska 99701)

The span (11 standard deviation) gold content of the Clusty Standard voin quarts; voin quarts (district vide); schiegt, and quarts diorite are: 0.342 z.030 ppm; 5.65 z 1.54 ppm; 0.361 z 0.189 ppm; and 3.73 t 0.682 ppm respectively. These values were obtained from 2.441 gold analyses of tocks of the Faithanks District does as part of the tolet in version of the content of the con of rocks of the Fairbanks District does as part of the joint University of Alaska-U.S. Geological Survey Meany Metals Project. The above values were derived by uning the geochesical sampling costant of inguantia and Switzer, coupled with cosputar scaping apperiments. This approach was faquired because of the Fairson distribution fallowed by gold in these rocks. Mean gold values for other rock types are also reported, but the number of supples was insufficient to provide a useful measure of the stendard error of the mean.

co provide a useful measure of the stendard error of the mean.

The commonly used stocks obserption (AA) analytical method, with aquarragia digestion, gives results for gold in good egreement with the first sensy method. Both methods gave values that were higher than those returned by the AA method and MS-Bry dispection.

Possible yrange alexant sensorial times are not the

Possible trace element associations among the transition sotals; A. Ba, Er; Sr, Y; A., Sb; Ng, Ph, Ats suggested by principal components analysis. There associations are contains because of the serious susping problems inherent in

# Geochemistry of the Cappa and Mater/all Coal Bads, Tyousk Formation, Cappa Coal Field, Cook Inlat Beglon, Alaska

RONALD H. AFFOLIER (U.S. Coological Survey. Box 25046, M.S. 972, Denver Federal Conter, Denver, CALIFERD BUZZS)

GANY D. STRIGERR (U.S. Geological Survey, Box
25046, M.B. 972, Deaver Federal Conter, Deaver,

Binatoen samples from the Cappu and Materfall cost bade in the lower Oligocoun to middle Miccosa Byanek Formation, Cappa cost field, Cook Inhat region, Alarka, were collected by the U.S. & Cookgiet Nature view of the Cappa cost field, Cook Inhat region, Alarka, were collected by the U.S. & Cookgiet Nature view of the Cappa cost in the Cappa for the Manager of the Cappa and A face channel samples from the Typach R-3 quadrangle. Proximate and ultimate analyses; hostoff-cobustion, mir-dried-loss, and forma-of-cultive determinations as well as major-aid minur-oxide and trace-wissent analyses were parformed an asch sample. The apparent rank for both the Cappa and Materfall coal beds ranges from both the Cappa and Materfall coal beds ranges from highest A to substantions B.

Sulfur content ranges from 0.12% to 40.3% Salected stemmes of convincement concern have the following ranges in parte per million: arsenic, 2.3 to 10.71 bers, litus, less them 0.1 to 0.2; monture, 0.5 to 2.0; and solonium, less them 0.1 to 0.2. These values auggoet that the Cappa and Materfall coal beds and comparable to other Alaska and weatern U.S. coals of stutter age, rank, and depositional environment.

#### Glaciology

### Response of Slue Clacier To a Perturbation in Thickness and the Flow Law of Ice

EXITH ECHILICYER (Division of Geology and Planetary Sciences, California Anathute of Tachnology, Passens, Calif. 91725) (Sponsory Barcley Kamb)

(Sponsors Barclay Rash)

The Sive Giscier, Clympic Hountains, Washington has undergone a substantial thickening and resulting increase in its velocity. It thus provides a unique catural test for giscier flow theory: what is the response of a temperate, non-surging glacier to a geometrical perturbation? Information regarding flow lew parameters in a poser-law type constitutive relation for its are obtained from a study of the resulting increase in velocity. In this spars observational data is compared with numerical models of glacier flow. The comparison enables an ostimation of the flow law parameters for temperature and a determination of the important factors governing the flow of the glacier. In 1975-35 the surface velocities and surface elevation along several transverse profilms were made of surface velocity, slewarion, and its thickness atong profiles spatially equivalent to those of the 1957-36 survey. Finite element methods using a nationary constitutive relation were exployed for interpretation of flow response.

The results, which differ atonification of flow response.

ation were employed for interpretation of flow response.

The results, which differ significantly from those obtained using a simple ice such model, about he importance of complex glacter geometries for interpreting the observed flow response. Details of both standy stare and omperturbed flow of Slow Glacier support a power-law type crosp relation. In addition a long wavelength averaging scale for surface slope and channel curvature are implied. Finite stands methods are shown to be accurate and efficient techniques for modaling the flow of a non-linear fluid in a channel of reslicit topography.

#### Holer, M. F., st 41. (1974) J. of Glac. 13, 187-212.

#### Giscier Motion Measurecasts by 35 cm fire-Lapse

MACRITH, PETER (Deceased) (Geophysical Inati-tute, University of Alaska, Fairbanks, AK 29701) RAYMEND, CHALLES (Geophysica Program, University of Machington, Seattle, MA 2812) HARRISON, WILLIAM (Geophysical Institute, Univer-sity of Alaska, Fairbanks, AK 29701)

In order to measure variations in gladier speed on the time stale of one day, we have devised a time-lapse camera mystem. It utilizes Olympus camera companents with suspented emposure, motor winds: and 710 warpaure back. Exposures are made automatically by an starm clock interfaced to the camera controls. The system is powered with 8 Dealle and can operate mattended for up to several manks. Must deployed with a 300 co lens and tample. Must deployed with a 300 co lens and tample at 100 m distance, the sequencial photographs can be seen the displacement of several controllers. Integraphs have been measured on travaling stage microscopes, or on a computer transating stage microscopes, or on a computer adjacent state usually used for measuring cloud thatter tracks. The speed and data recording affectency of the latter is obsertial, when there are a large number of fracts to be resoured. Up to if and course system have been deployed simultaneously in Varlegated Listler, a large rappeller account of the district AK. The tracks district the time of a suider speed up from winter to expect velocity in the speed up from proper periodic occurrence of minimum, of the grant first in the sent in the sent in the sent for the state of the speed up, and other less drassic calses of realing action latter in the summer.

#### PRECIPITATION VARIATIONS AT MOLVERINE GLACIER.

## C. Sugarne Brown (U.S. Geologica) Survey, Project Urfice - Giaciology, Tatora, Yash, 98402)

Pitterh-year temperature, precipitation, and mass-balance records taken at Moiverine discler. Alaske, indicate a substantially higher-than-areage writer precipitation for the hydrologic years 1970, 1477, 1980, and 1981. To determine the couse and the statistical significance of this high whoter precipitation, a long-term precipiestic claim record was necessary. Seward, Alaste, was latted with the 15-year Moivering record, and the precipitation record was best correspond to the statistical significance of the latter precipitation than series analysis of tools winter precipitation indicates those 4 years of bigs precipitation are mespected. The high total winter precipitation are mespected. The high total winter precipitation

tion was usually due to only one or two months with above normal precipitalian amounts. For 1970, 1977, 1980, and 1981 conthly precipitation amounts in excess of two standard deviations as calculated from the 30-year normal, were identified. Analysis of the near monthly 700-rb heights for these months showed an identical height pattern, regardless of in what month the excess occurred.

### Glaciological Research on Mt. Redoubt, Alaska M. STURM, P. MACKETTH, C. BENSON and J. Klewle (Geophysical Institute, University of Alaska, Fairbauka, Alaska 99701)

At Redoubt is a 3100 m high, glacier-covered interwittently active velcano, on the west side of Cook Inlat opposite Kensi, Alaska. Its 1966 eruption was accompanied by flooding of the Drift River. The flood maters carried blocks of ica, some of which were apparently from the unnamed glacier which flows north from the sume: reater of Ht. Redoubt. The flooding cause systemation of a seismic team working at the i h of Drift River on the shore of Cook Inla here an oil tanker terminal is now located. Our glaciological studies began in 1977 within the summit crater and were streaded to the terminus region of the glacier draining north from the summit in 1978. Accomplation at the summit in 1977 exceeded for more requivalent. The flow of ice in the lower part of the glacier, where it spreads out after leaving a narrow valley, has been measured every year since 1978. This part of the glacier was covered with volcanic debric from the 1966 cruption. The rate of ice flow is increasing and the ice is thickening in what appears to be a pulse of ice moving down glacier at a speed of about 500 m par year. The most recent set of measurements was made in early August 1982. If this pulse continues at its present speed it could reach the terminus of the glacier within one or two years. If it causes the terminus to advance by only 60 m it could doe the Drift River. Glacier-demed lates have formed at this location in the recent geological past. Such glacier-demed lates are unstable and cause flooding when they break loose. The potential hezard to the tarker terminal: at the mouth of Drift River needs to be evaluated.

## Reassassment of Winter Pracipitation in Alaska by Use of the Vyoming Snow Bage.

G. CLAGETT, C.S. BENSON, \*\* and C.V. SLAUGH-\*\*Soil Conservation Service, U.S. Department of Agriculture, 2221 East Northern Lights Blvd. (Suite 129), Anchorage, Alaska 99504 \*\*Geophysical Institute, University of Alaska, Fairbanks, Alaska 99701 \*\*\*Institute of Northern Forestry, U.S.D.A. Forest Service, Fairbanks, Alaska 99701

Forest Service, Fairbanks, Alaska 99701

Precipitation gages shielded by the 'tyoming Blov Fence' developed by Richard and Larson have been used in Alaska since 1975. The Blow Fence consists of two concentric snow fences (radii 10 and 20 feet) built around a precipitation ages. The first one in Alaska was built in Movember 1975 at Barrow. Five more were built-during the 1975-76 winter on the Arctic slope, there are more than 25 of them in Alaska and the Yukon Territory now. Measuring pracipitation in a wind-swept region such as Alaska's arctic slope where the total quantity is small, and nearly BDC cases as snow, is a complax problem results from the Myoming snow gage used adjacent to unshielded Weather Bureau gages indicate that the long-term records are too log by a factor of three. This important result has already been used in our afforts to determine the flux and transport distance of wind-blown snow on the Arctic slope.

The gages are now being used in other exposed windswept parts of Alaska. The largest snow pack measured by them is on Kodiak Island where 4 to 5 to 0 snow falls. Recently installed gages utilize continuous recording devices (with hourly values recorded) rather than cans measured by weighing them. Continuously recording gages have been operated by the Forest Service (USDN) in the Caribou-Poker Creaks Research Matershed since the winter of 1976-77. The first Alaskan gages were built as part of a research study on wind-blum snow; they have been turned over to the Soil Conservation Service (USDN) as part of its overall evaluation of som hydrology in Alaska. The long-term value of the gages has been deson-strated, but some in the Arctic now need major repairs and/or replacement.

# Climatic Fluctuations and Water Yield From Glaciated Besins in Alaska

S. A. BCHLIRG (Geophysical Institute, University of Alaska, Fairbanks, Ak. 99701), (Sponsor: Kolf Jayansera)

Runoff in glaciaed basins is subject to large fluctuations with rester long time scales. In the Susitne Basin, for instance, which is 43 glaciated, about 13% of runoff is believed to be coming out of storage in the glaciers. The climatic response of the glaciers, and thus of long-term and short-term runoff, is thus of considerable interest.

Precipitation and glacier ablation in Alaska are not unconnected. The major source of both heat and moisture is the Pacific Ocean. An increase in transported Pacific air into the basin would increase precipitation and ablation at higher elevations, and probably increase the runoff substantially, even if the glaciers began to grow again. On the other hand, more Arctic air would reduce both pracipitation and ablation at all elevations. Major changes in total runoff are thus possible.

## Underwater Assustic Evidence of Olacial Solamic Evanta in Olacier Bay, Alaska PAUL B. NILES (Bolt Beranek and Newman Inc. 10 Houlton St., Cambridge, MA 02238) CHARLES I. MAIME (BBN Inc.)

High level impulses of underwater sound cacurring as frequently as 1-4 times per civilities were detected in Clacier Bay, Alaska during a measurement project to define the underwater acoustic environment in that region for National Marine Fisheries Service and National Park Service. Analysis of these impulses decomparative signal-to-noise ratios as high as 40 dB, significant broadband energy from below 20 Mz to above 2 kMz and the presence of pure tank components. The character of the impulses is relatively invariant with locations within the Bay area.

We hypothesize that these events are associated with the many active glaciers in the region and are the result of stickslip action generating seismid energy at the ice/rob interface. That energy is then propagated through the bedrock and radiated as sound into the water colour through the walls and/or bottom of the flords and inlets. Acoustic instrumentation used included a sombuoy and an omnition used included a somboury and an omnition. Amalysis of simultaneously recorded data from that two geneor systems provides acts directional information relating to the source of the events.

Bata are presented describing this phe-nomenon in detail and relating it to findings of others who used scopholes on and near glaciers in other recipes;

An Intriguing Glacial Feature in Broad Page, Alaska,

# S. A. BOWLING (Geophysica) Institute, University of Alaska, Fairbanks, Ak.

An August snowstore in Broad Pass, Alaska left a pattern of snow and bare ground resembling giant ripple parks on the southeast side of the Parks Highway. U2 images of the area showed a drustinities feature roughy 6 km long and 800 m wide at the broadest point. The large feature has two major longitudinal troughs, giving it the appearance of two or three small featur arranged in echelon, and is crossed by the appearance of two or three small features arranged in echelon, and is crossed by numerous transverse ridges and troughs which were probably respectively for the rippled appearance. The transverse troughs are in most cases continuous across the crest of the larger feature, with a spacing of the order of 50 m. The feature is undoubtedly glacial in origin but the conditions responsible for the forestion of the transverse ridges are uncloar.

Characteristics of subscript sediment flow dapos-its, Matennaka Glacier, Alaska.

DANTEL R. LAHSON (USACPREL, 72 Lyme Road, Honover,

Subserial sediment flow deposits bear characteristics that distinguish them from other dismictons deposited in the sedimentary environment of the Matanuska Glacier, Alaska. These properties are developed by the sechanics of initiation, movement and deposition of sediment gravity flows. Active actioner flows are characterised by outtigle grain support and transport mechanisms that vary in importance with the water content of each flow's matrix material. These variations are generally reflected in the properties of the resulting flow deposits. These deposits can be differmentiated into six sedimentagic units. Each unit is distinguished mainly by variations in grain size distribution, sedimentary structure, public fabric, gravel-mice clast concentration, and presence of lesses or aggregates of each content in the sediment flow deposits are further distinguished from other classic dissections.

#### Gravity and Magnetics

Juan de Face Plate Map: Gravity

The latest addition to the Juan de Fuca plate was series is a compilation of gravity data. Contours at 10 mgal intervals are printed onto the standard topographic base (1FP-2) at a scale of 1/2,000,000. Values shown are Free-Air at see and Bouguer on land with reference to IGSN71 and Geodetic Poference Field 1967,

The principal gradients occur along the Mendacine and Queen Charlotta fault zenes but a series of extended north-south appealies characterise the convergence zene along the Menhington-Oragon coast and the tonat Runges. Elsewhere, as expected relations between gravity anomalies and topography tend to be direct at see and inverse on land.

### Gravity Surveys in the Canadian Cordillorn R.P. BIDDINOUGH and B.A. SEEMANN (Pacific Geometence Centre, P.U. Box 6000, Sidney, B.C., VSL 482 Canada)

The Dept. of Energy, Hines and Resources of the Canadian Rederal Cove, has been conducting routine regional gravity surveys in the Canadian Cordillers since the 1960's. Station spacing is at 12-13 ke and measurement spacifications require ± 50 m horisontal and ± 3 m vertical positioning.

The nature and quality of existing topographic control make these requirements difficult to achdows. Mathods used over the years have included stituetry, whete-bridging and inortial positioning. Coupled with uncertain visibility and flying conditions, surveys are slow and expensive. Mevertheless regional coverage is now complete up to 5°M and plants are being mode to finish the remainder of the region through the Yukon and MV Territories over the next 20 years.

#### Gravicy Survey of the Little Spokene River Yolley, Washington

DAVID A. SIKFFY (Alasks Region, Minorale Manusument Ecrvice, U.S. Department of the interior, 800 A Street, Suite 201, Anchoragu, Alaska 99501)

On a Hougar gravity map the Little Spokene River Valley appears as a broad trough-shaped, negative Senguar ancesty matrowing morthward. The autrounding highleads, which sto composed of Createcases granites and Fracamberian mannerphica, appear as local "high" Sougaer annealies. Beanit flow remanns (Columbia River Basait Group) and their sedimentary interbeds ("Latab Fracation") distributed throughout the valley floor appear as local "low" mougaer annealies.

Residual Bouguer annealiy maps revenied a burled basel tongue accessing setward from Vivilladian Prairie into the glacial drift-filled Hill-ward Trough. This tongue dems the ground water flowing northward through the trough and causes its hydraulic gradient to increase toward the lower Little Spokene River Valley where it discharges.

charges.

Based upon the gravity maps and the local aquifar characteriacies, regional ground-watar flow patterns were identified. These patterns augment that the little Spokens River receives additional recharge from ground water flowing westward through glacial drift found between Green Bluff and the Peons and Fleensent Prairies, from ground water flowing eachward through glacial drift between the VILM Rose Prairie and the Bear Park region, and from ground water flowing southwestward through shallow, glacial drift-filled walleys morthwast of Deer Park.

Neither the Bonguer nor the residual Bonguer filled valleys northeast of Deer Park.

Matther the Bonguer nor the residual Souguer aroundly maps indicated direct glacial erosion during the Quaturnary within the study area. Evidence for this conclusion is that the Unshaped valley normally associated with direct glacial erosion was not reflected by the gravity maps. Also the presence of numerous baselt flow remnants found throughout the Little Spokena River Valley suggests no direct glacial erosion.

# Marine Magnetic Survey of Pine Structure Associated with the Leach River Fault in Coastal Waters off Victoria, 8.C.

JOHN M. GILLILAND (Physics Department, Royal Roads Milltery College, PMO, Victoria, B.C., Canads VOS 180; W.T. MacFarlans (Physics Department, Royal Roads Military College, PMO, Victoria, B.C., Canada VOS 180)
M.J. PRES (Physics Department, Royal Roads Military College, PMO, Victoria, B.C., Canada VOS 180)

Ninety sugnatio profiles crossing the scaward sxtansion of the Lacoh River Fault have been obtained wains a total-field magnatumeter cowed in the cosstallysters off Victoria, Switten Columbia, the region between the Coburg Philacola and Trial Islands, Good Postford Rockgrey was schieved firing. positional scottage was sohieved using

a Trinjender maridation nystem linked to an enhant deficie expeter.

The result to data clearly identified the position of the least better Fault. The fault trace runs parallel to the laptical which is about the lies Coberg Pentumba to clover Point at a ream distance of about 17 km, and continues on a straightful trace heading or about 1125 from beyond clover Point.

closer to share, the data indicates the position of the Servey Hountain Fault, and clarities the interaction between the Leech River and Survey Hountain Fault systems, which converge off Brotchin Ladge.

#### Meteorology and Hydrology

Monttering the Pulligren Mater Content of Soil JIAN SILIS and Israila' L. PARE (inititute of Mitut Recontros, Lutertuity at Alaska, Fairbanks, Alaska 98/01)

Time downin retin towerty (100) in a technique that can be made to indirectly resource the function acts content of needl. The reportmental IDA weeked was used to resulter the materials util loss that deter content of a sufficient liquid water content of a sufficient located. The apparatus constain of probes located particle. The apparatus constain of probes located in the neit, transmission lines, and an instrument to generate an electromagnetic wave and measure the travel time through the reduce fucil in this cases. We have experiented with two types of transmission lines: But obey parallel line and 50 day constal line. Various configurations of probes were installed horizontally at various depths in the neit to a manter affect of one of probes were installed locational configurations of probes were installed locationality at various depths in the notifice a maximor depth of one meter. Prior to freeze-up in the full, three plots were irrigated to vary the notification content; a fourth well-drained nite unread as a content; a fourth well-drained nite unread as a content.

When the content is the uniform water contest ware taken at approximately five-week interests during the whiter and each day during the obligation perfect. The readings were conversed to

liquid water content for the noti studied by uning a cultivation curve that was developed in the laboratory utilizing a pressure plate apps

In general, the technique results in good delineation of the uniform coincider content with depth. The advantages of this method are that it does not influence the worting and drying of the soil, it does not affect the freezing and thawing of the world, it relies on a physical property that in a function of the tiquid water content, and it is nondestructive. This technique has been very homelical for understanding

# Hopitoring the 10th by trie Properties of Snew in the Field Uniting Time Postation Relieving try

JEAN STAIN CIRCLETURE of Mater Resources, Not. vorsity of Alacka, Englishmen, Alacea 99701) DOUGLAS L. EAST timestance of Major Percorcus University of Alacka, Entre men, Alacka 99701

Time domain reflectorates (198) has been re-cently applied to measure indirectly the arount of liquid senter in the soft. The technique measures the complex director constant, which is proportional to the arount of liquid senter at the proportional to the arount of the liquid senter in the liquid senter of the liquid senter of the liquid liquid to the same with singular mechanical determinant of the same with singular mechanical Installed in the same with contact to contact al distribute and to explore the locatifity of using the fibt technique to contact the liquid water content of the same and the percolation of method or the mose and the percolation of method or the mose and the percolation of method or the same and the percolation of method or the same black of the same and the same and

#### Hydrologic Hadel ing of the Luturalia Plateau Bagalia

P. H. Dave (Mattalle Pacific Northwest Laboratory, P. O. Rox 999, Rithland, WA 99352)
C. R. Cola (Mattelle Pacific Northwest Laboratory)
F. W. Bond (One toll parties Nerthwest Laboratory)
D. A. Zismerman (Raitelle Pacific Northwest Labo

D. A. Simpsiman (Antella Parille Northwest Lab.)

The Office of Racinal Maste Indiction (CMM) itrorted the Anneamonal of Effectiveness of Goolegic Louistion Systems (Artill) Programs of Goolegic Louistion Systems (Artill) Programs of Goolegic Louistion Systems (Artill) Programs to conduct a technology domains at the of carrier perforance assentances, techniques (or the Repartment of Resty (IMM) an applied to a merical waste repository in the Columbia Plateon Baselin. Rypediotical repository in the Columbia Plateon Baselin. Rypediotical repository and the Columbia Plateon Baselin. Rypediotical repository and the continuous continuous and the state of Hamilington, Published hydrologic and the state and in the manuschement gathered in 1979 or carlier. The hydrologic model of Pasos Basin. This paper discussed the parise of Pasos Basin. This paper discussed the regional bodd.

An estimate of the assemble of Pasos Basin. This paper discussion for the desparabality the ground-water systems was required to bound the transmissivity values and to estimate the transmissivity distributions for the desparabality of the paper the desparabality of the paper of the desparation of the paper of the desparabality of the paper of the paper of the desparabality of the paper of the pa

# Groundwater Flow and Transport Characteristics of Flood Basalts as Determined From Field Tracer Experiments

L. S. LEONHART, R. L. JACKSON, D. L. GRAHAM (Rock-Well Manford Operations, Richland, WA 99382) G. M. THOMPSON (University or Arizons) L. W. GELMAR (Massachusatts Institute of Tech.)

In conjunction with a U.S. Department of Energy Sponsored evaluation of the Columbia River Basals in terms of their suitability as a radioactive waste-storage medium, a series of groundwater tracer experiments are being performed. The test location is in south-contral Mashington at the federally-owned Manford Site. The data gathered from these tests are being used within numerical solute-transport models developed to predict assembly and the performance of the proposed waste facility.

avaluate performance of the proposed wasts facility.

To date, two tests have been performed within the McCoy Canyon besait flow top of the Grande Ronde Benait Formation. Emphasis has been placed on determination of hydraulic parameters. Sociating longitudinal dispersivity (a) and effective thickness. Certain qualitative inferential manual about casion-achange phonomena. Both tests utilized the two-nell retirculating tracer technique within paired boreholes separated at depth by approximately 17 m of formation. The depth of the test interval ranged from 1000 to 1001 m below land surface. The first experiment utilized an iodine-131 tracer and the second utilized pothesium thiocyanate. Both tests displayed similar, results in terms of the a and the values a values ranged between 0.6 and 1.7m and where obtained enalytically by matching type curred that similate concentration variation at the gasting wall. Laboratory analyses by the discrete

water samples for selected cations indicate that the armival of the potassium fon peak at the detection point was accompanied by a significant increase in sodium ion concentration ever back-

# Senk Recession and Chennel Changes in the Area of the North Pole and Floodway Sill Groins, Tougas River, Alsoka

LAWRENCE W. GATTO (USACRREL, 72 Lyme Road, Ranover, New Hampshire 03755)

Ranover, New Hampshire 03755)

The objectives of this project were to measure bank recession and desortise channel changes before and after groin construction, and to evaluate relationships between recession, channel signation, groin construction and discharge. Aerial photography was used to map historical bankline positions and to document the channel changes from 1948 to 1981.

Host bank recession casar the Sorth Pole groin occurred along the north channel prior to 1973 when the groin was built. The groin diverted the channel away from the corth bank, sithough the north channel appears to be resetablishing a mandar at the end of the groin. Bank erosion along the south channel increased slightly after groin construction.

Bank recession along the south channel mast the still groin awareged about 6.4 m/yr before and after groin construction. Rowever, prior to construction most of the recession occurred along the north channel. South channel bank tecassion occurred along the islands in the north channel. South channel bank tecassion avaraged 3.5 m/yr from 1970 to 1979, recession avaraged 7.6 m/yr from 1979 to 1981. This suggests that the south channel has a larger discharge alone construction in the harden.

# Technique for Nutrient Flux Estimates in a River Channel

L. John Zeeun (Water Quality Branch, Inland Matera Directorate, Vancouver, B.C., V&E 299).

Since 1976, a monitoring program of nutrient loading has been carried out by the Mater Quality Branch, Pacific and Yukon Region as an Integral part of the Canada-British Columbia Geanagan Basin Implementation Agreement. The primary goal of the program was to design a method for improving the precision of nutrient load estimation in order to provide water management with a reliable measure on nutrient transport by the Geanagan River to the valley lakes located downstream from the waste treatment plants.

Two sampling methods were used for measurements of concentration of primary nutrients, almultaneous and asquential methods. The simultaneous method, beard on collection of sample replicates, permits the calculation of confidence limits of the concentration means and the total loads of nutrients passing through the channel cross-section. The sequential sempling method, used to obtain time series records of single point concentration measurements does not permit the calculation of confidence limits. Precision of the load data derived from sequential sampling method is, therefore, periodically compared with the results obtained by simultaneous methods. Consistency of load data is determined by the comparison of results obtained by these two sampling methods and statistically proved by

Chacho, Edward F., Jr. (U.S. Army Cold Regions Research and Engineering Laboratory, Ft. Wisowriphe, AK 9716 Copensor, C. Dissonter

The Tanana River is a glacior-fod alluvial river with an avorage annual peak flow of 1700 m<sup>3</sup>/s near Fairtanka, Alaska. The channel pattern of the river is braided upstream of the study reach and approaches a meandering channel through the study reach. Trues-sections have been surveyed on the river since 1977 in conjuction with the Corps of Engineers Chena Pleod Control Project. The surveys show up to 10 m/year of lateral migration of the main channel. In some reaches of the river the channel cromasection has changed drammatically in both the vertical planes, aggredation or degradation, and the horizontal plane, channel shape and thalway adjustion. The analysis presented shows the relationships between channel geometry and changes in the river course due to anostruction setivities in the river.

# Sydrology of Borth Slove Coastal Plain Streams SPERT T. DRAGE (Peratroyloh & Mottingham, Inc., Anchorage, Alaska 99503) JEFFREY F. OILAMN (Peratroyloh & Hottingham) DAYID HOUH (Peratroyloh & Mottingham) LESLIE ORIPPITHS (Peratroyloh & Mottingham)

This paper presents the gameral hydrologic characteristics of the streams located on the coastal plain between the Kuparuk River and the Colville River on Alaska's North Slope. The data presented in this paper were gathered over the last five field seasons by the authors and others while working under contract with ARCO Alasks, Inc.

Following a general discussion of the geographic and olimatic setting for these streams, there follows a discussion of several important hydrologic parameters which define the uniqueness of atream flowing in this environment. From discharge measurements, values for typical stopes, kanning's roughness factors, and Corlolle energy coefficients are presented.

Finally, a new flood frequency analysis for these streams has been developed uping a Log Pearson Type III distribution in conjunction with a regional skew weighting analysis. The result of the analysis is a set of frequency curves for discharge per unit area vs. drainage area.

It is hoped that the data presented in this paper will serve as a baseline for future studies in North Siope hydrology.

# Urban Air Pollution During Ice Fog Episodes T. A. BOSIAK (Beophysical Institute, University of Alaska, Fairbanks, AK 99701) C. BENSON, S. A. BOMLING, C. FEIST, T. OHTAKE and B. SHAW (University of Alaska, Fairbanks).

Urban air pollution during winter at high latitudes can be significantly different to its physical and chemical properties as compared to the commonly studied wormer temperature counterparts. Chemical, physical and biological tests of air pollutents in Fairbanks, Aleska from the ice fog episode of December, 1980 are presented.

The air pollution products tend to be reduced, rather than exidized. Mitric oxide predominates over nitrogen dioxide. Ozone is totally expended Armonia concentrations can be higher than the nitrate content in the fallout, Melted ica fog and snow is basic rather than actdic. There is some evidence for nitroscemine production, and the melted ice fog is mutagenic. On the Mateorological chereateristics of polluted six masses at Barrow, Alaska

W. E. RANZ (Geophysical Institute, University of Alasks, Fairbanks, Alasks 99701) (Sponsor: Kolf Jayawaets)

Astonois collected at Barrow, Aleska suggest that the Arctic atmosphere during winter/apring contains detectable amounts of anthropagemic pollution from mid-lactudes. In most cases peaks of concent close of excess vanadium and access manganess can be associated with quasi-permistent surface circulation patterns creating distinct pathways from the source areas to Sarrow. Examples of mateorological characteristics of air masses assumed to carry the pollutants are presented. From surface and 850 mb data it appears that these air masses are associated with colder, less cloudy, more windy, and more saticyclonic canditions than the monthly average. Due to insufficient data it is not yet possible to differentiate polluted air masses that how entered Barrow along different transport pathways.

### Mixing Heights in Countown Fairbanks During Episades of moderate to Severe Air Pollution

S.A. BOWLING (Geophysical Institute, University of Alaska, Fairbanks, Ak. 99701,)

On these occasions during the 1981-92 winter, we succeeded in measuring temperatures in the fist 100 m of the atmosphere in and outside of Fairbanks. Temperatures warmer than the background were observed to extend no higher than 40 m in the city soundings. On the two soundings with CD concentrations above 10 pps, normal lapse rates were observed only in the lowest 10 m. City measurements were made within 150 m of the main carbon monoxide monitoring intake, so the mixing heights measured, which are considerably lower than had previously been estimated, should be representative of those associated with high CO levels in Fairbanks.

#### Folds, Pleats, and Halos

WALTER TAPE (Department of Mathematical Sciences, University of Alaska, Fairbanks, Alaska 99701)

Many ice crystal halos in the sky can be visualized abstractly as folded or pleated rubber sheets. The halo function is the mapping that expresses points of light on the calestial sphere as a function of crystal orientation. To form a given halo, the halo function starte with a certain surface, tepresenting crystal orientations that produce the halo, then folds or plasts the surface, and then lays it on the celestial sphere. The halo tends to be brightest at the folde and pleate, since this is where relatively many crystal orientations are sending light to the eye.

#### Oceanography

MIZEX: Same Implications with Respect to the Beaufort Sea

The Marginal Log Zone Experiment (MIZEX) is an interdisciplinary research program which seeks to better understand the processes which occur at and near boundaries between sea ite and open water. Some specific problems being addressed are those relating to the seasonal and interannual varietions in ice adde locations, the oceanographic and meteorological processes unique to ice adges and the characteristic properties of ice along the edges. To acquire information pertinent to these problems major field, analysis and modeling programs are planned for the Bering and East Greenland Sea marginal ice zones.

Results from the MIZEX program will be directly applicable to many aspects of the Beaufort Sea Results from the MIZEX program will be directly applicable to many aspects of the Beaufort Sea summer for edge region. Increased understanding of the complex interrelations between northern hemisphere ice adge location and large-scale meteorological parameters will anhance long-term pradictability. The results of analysis and modeling efforts on the edge related frankl, thou tures will bear both upon studies of small-scale ice mations and biological productivity at and near the adge. New information on ica melting and freeling processes will aid in the prediction of small-scale ice edge behaviour and will enhance our understanding of oil-ice interaction. Finally, development of mothods for modeling sea ice behaviour in the marginal ice zones will enhance both short-term predictive models and the ability to estimate hazards posed by the ice to structures.

# Polynya Davolopment and Pioe Velocities in Response to Winds in the Eastern Bering Sea, March, 1976

LYN MCNUTT (P.G. Borcho and Associates Limited, 640 lith Avenue S.W., Calgary, Canada T2R 082)

Studies of satalita imagery show the locations of recurring winter polynyss in the content Bering Sea. They also provide information on fice velocities in these areas for the same times, and indicate a predominant north-mortivesaterly winter wind regime. Clouds obscurathis region during periods of southerly wind flow and bims the data to cloud-free conditions. Occasionally, clouds remain in the southern pertion of the imagery, exposing the northern springly for molysis. These conditions existed in March, 1976. Using the HETLIS program, windspeeds superimposed on polynys and flow maps show the correlation of ice motion with the shifting wind and indicate the response time from the onset of the winds until the changes in the features occur. The flow motions seem correlate well with data from resorts stations taken on the ice during similar conditions. Studios of satullite imagery show the loca-

# The Oceanography of the Bering Ses Ice Bine in Spring

R. J. WISHAMER (Institute of Marine Salence, University of Alsoke, Fairbonks, Alsoke 99701) V. ALIZANDER (Institute of Marine Salence, University of Alsoke, Fairbonks, Alsoke 99701)

Seasonal pack ice edge somes are nir-ice-ses frontal systems that offer the opportunity to study the coupling of meteorological, and physical amb biological occamographic processes that are concentrated in time and space. In spring 1932, e truise to the Berieg ice edge some was made to address questions on the tole of physical processes in mediating spring phytoplantics blooms. Physical (TG, 8%,) and bischmalcal (chlorophyl, NO, etc.) occamographic date are presented addressing the role of spring toe main in the spring bloom in this frontal system.

# Tammants and Storm Suress in the Canadian Arctic and implications for Offshore Work in the Besu-fort See

T. S. MURTY (Institute of Geen Sciences, P.C. Box 6900, Sidney, British Columbia, V&L 482)

Major marthquakes capable of generating taun-cuts have occurred in the pust at various loca-tions in the Canadian Arctic, including the Beautors Sea. Although not trequent, the teuncoastal and offshore works. Even more serious than the causanis are the store surges that occur quite regularly in the Seasten surges that occur quite regularly in the Seasten the Araric, and especially in the Seastent Sea. For example, twenty-neven significant surges with amplitudes of one maker or kreater have occurred during an elevan year paried. The negative store surges can create problems for navigation in the shallow regions of the southern part of the Seaster test of the S I and offehore works. Even more serious

to eummer pariods. Probability estimates used using various techniques when thet, in the Southern Beaufort Sea, return pariods of major surges are about thren to five years. To study the development, propagation and amplification of stotm surges, it is necessary to resolve the topography adequately and this can be achieved through the development of irregular triangula

I.J. Weingartner (Woodward-Clyde Consultants, Anchorage) J.H. Colonell (Woodward-Clyde Consultants,

To provide a characterization of augment occanographic conditions mean diskok foint at the west and of Simpson Lagoon, hydrographic and currant data were collected during the 198 open-water season. Shallow depths (-3m) and small satroncomical tide (-30 cm) in this area cause it to be primarily a wind-driven mystem, similar to other manshore waters of the Beaufort Sea. The influence of the nearby Colville Haver (largest river on the Alasken Borth Siope) is evident in major conclusions drawn from this study:

(1) Fresh water is advected into western finpson Lagoon in substantial quantities during westerly wind events, with lowest salinities occurring northeast of Oliktok Point due to deflection of the plone by the point;

(2) Strong horizontal and vertical density gradiouss are established as a result of the confluence of marine and rivertue waters in this area; serving to delicit clearly the boundaries of

Results serve to underscore other observations of the dynamic and responsive character of the neatthors Beaufort Sea.

#### Prudhoe Bay Causeway

J.M. Colonell (Woodward-Clyde Consultants,

Ancourage:
P.A. Mangarella (Woodward-Clyde Consultante,
San Francisco)
T.J. Weingartner (Woodward-Clyde Consultante,

Oceanographic data collected around the 4-km long gravel-fill causeway at Frudhoe Bay provide losight to the inpact of such structures on the nearshore Beaufort San anvironment. Hydro-graphic (CTD) surveys and rime series of curtants, conductivity, and tempetature were obtained in August-September 1981, a period referred to as the late open-water season.

Because of its shallow depths (\*5m) and email surroncutcal rids (\*20 cm), the mearshore featufort. See to emeantially a wind-driven system. Prevailing reaseriles and storm-related westeriles are the wind regimes of interest. The northward orientation of the feature of the contraction of the contraction of the contraction of the second of the contraction causeway, in combination with the generally east-west configuration of the constitue and betrier telends, cause development of dynamical features that correlate well with wind

(i) On the windward side of the causeups an offenore-directed buoyant jet is caused by interruption of the languabers flow.

(2) Upwelling occurs on the les side of the causeway.

One consequence of these features is that emiliately differ from one side of the courseway to the there is no per other effects of the causeway include incannailication tidel currence in its vicinity and alteration of flushing times for the adjacent

#### The Alaska Constal Current

TECHAS C. ROYER (Institute of Marina Science University of Alseka, Fairbanks, Alseka 99701)

ing the Cuir of Alsers to a phenomene that reaponds to many of the region's geological
features and influences its ocsanogzaphic processes. The barcolinic portion of this current
displays a sessonal response to the constraint
response to the current is also codified by the
local winds. The runoff here is dependent not
only on the precipitation rate but because
approximately 202 of the drainings area is covered
with electers. It is also developed to main tempapproximately ZUE or the second on sir temp-with glaciers, it is also dependent on sir temp-

oreture and insolation.

There are many similarities between the
Alsake Costal Current and other high latitude
ourrents, such as the Borwagion Costal Current,
Rowever, it is unique in that the wind system
over the Gulf of Alaska never reverses the costs.

over the Gulf of Alasks never reverses the constal flow.

The constal current is the major feature of
the constal circulation. It controls the unarshore and acturing distributions of sediment,
nutrients and marine organisms. Because constal
waters from the Gulf of Alasks enter the Earing
and because the Beautory Sea, this constal current,
acts as a gource for these areas. It can also
be considered as a major source of low salinity
water for the North Pacific Ceans. The implicattion is that this constal feature could affect the
deep ocean circulation.

New rescarch efforts are underway to define
measure better the oceanographic properties of
this flow. Mydrographic, current mator, metorological, chemical and plankton studies are being
planned.

#### A Case of loftex

<u>RECORY A. YAYDA</u> (Institute of Marine Science, University of Alaska, Fairbanka, Alaska 99701)

The Alasks Constal Current be a flaredly engagele percew band of brackish unear which flows wearward along the northern Gulf of Alasks bordering the north southern count of Alasks. Its source inputs are the high rate of freebuger rimoff from the coast and the inmidious languages assertly wind. The fractional factions assertly wind. The fractional factions assertly wind, the fractional the drivers a longuabors beronicing current. The shoreward Rimms transport, which results from the longuabors wind, tends to actract the brackish warer into a marrow band and thus maintains the integrity of the flow.

Until respect the sateant of the collusion between the longuabors examport and the wind was unknown. This peace presence an energy believe to securial the relative contribution of wind and frashwater to the longuabors.

### Deep Water Circulation in a Sub-gratic Florid: Beeston Bey, Alsaks

DAVID L. MESERT (Institute of Marine Science, Volveratey of Alsoke, Pairbonke, Alsoke 99701)

Current meter and hydrographic data are thed to describe the circulation in Senaton Rey, a silled ford in southeastern Alaska. The region has palatively high precipitation rates and large tides. A dominant fasture is a net outflow near all depth during much of the year, the conflows at the sill have been operwed, the conflows at the sill have been operwed. during times of high local discharge and during bottom enter renewal. Another dominant feature in the inflow at 15 to 30 m. This inflow is generally considered to be a salt continuity

Speculations as to the causes of the sill-death outflow are presented and related to the phase. ' circulation.

TWO APPROACHES TO WAVE HUNDCASTING Pro, Victoria, B.C., VOS 180)

The results of two approaches to hindosetting wind waves in limited fotch coastal areas are presented and compared. Both methods was adjusted observed wind records which are representative of the wave generating area. for most coastal engineering applications, a knowledge of the frequency distributions of wave batchts and pariods is required. The two approaches employed to reach these

(1) determine the frequency distributions of waves bindcasted on an hourly basis from hourly wind speeds and directions observed over a ten year

(2) hindcast the frequency distribution of waves from the frequency distributions of wind speed and direction over the same ten year period. The latter method is much simpler but assumes that the wind waves are fatch limited and not dependent upon the wind duration.

The two results of the wave hindcasts for two coastal locations are compared in details Coros, Vancouver Island where fotches are less then 50 km in the Strait of Georgia and southwestern Newfoundle where fetches are up to 350 km in the Gulf of St. Lewence.

# henthic Eddy Diffusivities and Gas Ex-change Rate Estimates using RADON DAVID M. GLOVER (Institute of Marine Science University of Alaska Pairbanks, Alaska 99701) WILLIAM S. REBBURGH

The distribution of radon-222 and radius-226 was investigated in the PROBES project area of the southeasters Bering Sea. A large and fairly uniform radon-222 flux from the sediment leads to a small or nonexistent radon deficiency at the sea surface in the shallow regions. Integrated radon-222 deficiencies have been used to calculate stagnant film thicknesses and ges exchange rates, so this high bottom radon flux complicates calculation of gas exchange rates here. Tidal mixing near the bottom is ac intense that it requires two-dimensional modeling to explain the benthic eddy diffusivity date. Padium-226 in the area has two distinct signatures with the off shalf waters being approximately a factor of 2-1 higher than the on shelf waters. We have exploited this difference in shelf breat fine structure studies. A cross shelf section of radium-226 has maximums and minimums suggesting influence by biological activity.

Partial Pressure of Carbon Distille from ph and Salinity

T. A. GOSINA (Geophysical Institute, University of Alaska, Fairbants, Ar. 99701) J. J. Filler (Institute of Marine Science, University of Alaska, Fairbants, Az. 99701)

The partial pressure of cerbon dioxide in sea water can be rapidly and accustely (a 6 ppm) determined from a corrected in-situ pH and the salinity (a 0.2'/\*\*) as shown in equations (1)

 $PCO_2 = a pW_c$ 

pHc = pH + (pH × sal/1000) (2) There will be a discussion of the sea water carbon dioxide-carbonate system from a slightly different perspective. Comparison of PCOs as determined from classical calculation, direct obdetermined from classical calculation, offect ob-servation and this new method will be presented. The new method has been successfully employed since its discovery in 1979 for deep as well as surface water samples. On the M.B.5. reference pli scale the yalves for "a" and "n" (equation 1) are 3.98 x 10<sup>20</sup> and -19.568 respectively.

Seismology

Belanic Caps slong the Queen Charlotte Fault G. C. ROGERS (Pacific Geoscience Centre, Earth Physics System, P.O. Box 6000, Sidney, B.C.

Relocation of sarthquakes that have occurred along the Queen Charlotte Fault since 1900 indicates that two saimic gaps may currently sgist. One which has previously best identified lies to the morth of the Queen Charlotte Islands between the north and of the aftershock some of between the north and of the aftetaback zone of the 1949 Queen Charlotte Imlands earthquake (M = 6.1) and the 1972 Sitks earthquake (M = 7.6). It may be up to 150 im in length. The other get is loneted between the south and of the 1949 afterwheck zone and the 1970 Cape St. James earthquake (M = 7). This is a region about 75 hm in length, which has not experienced a major earthquake since at least the turn of the century. Since 1950, it can be confirmed that the region has also been devoid of moderate whoths. Earthquakes with magnitudes of about 7-3/4 and 7-1/2 respectively, would be required to completely fill these two gaps.

# Tree-blog Evidence for Upilft At Loy Cape, Aleska, Related to 1879 Earthquakes in the Takataga Seizalo Gap

G.C. JACOBY and L.D. BLAN (Tree-Ring Laboratory

This study and others show that tree-ring analysis can provide information about past major earthquake events. If occurrace and twoursmost flare, pra-historic events can be determined by tree-ring analysis, this information will be in important addition to the paleoseismological

remord.

Great earthquakes occurred in September 1899 on the southeastern coart of Alaska mear Joy Cape (west shore of Joy Ray), an area now included within the vakatage seismic gap. Due to qlactel coverage of the present bay area in 1899 and to the starouty of observers, tectonic deformation at Joy Cape related to these earthquakes went unrecorded.

at Loy Cape called to these earthquakes went unrecorded,
Tree-ring analysis shows improved radialgrowth rates after 1900 for trees at two locations on the seward satule of a hypotherised
pre-1999 wave-bests shoreline. The oldest trans
found on the surface between these trees and the
present shoreline started growing in 1902. In
soldtion principal components unalysis of the
tree-ring data from 1890 through 1920 indicates
that the trees at the terrace margin show a common low-frequency growth trans darkets from
inland trees, The tree-ring evidence and the
typecorphology can be explained by local uplift at
190 Cape and/or by rapid influx of eachments from
avalencied headwater, areas and maitwater from retreating gledders.

### Saismic Activity in the Vicinity of Anchorage, Aleska, 1972-82

We have reviewed earthquakes located within 100 km of Anchorage during 1972-82, utilizing

1.0

# 1. C. LAMM. C. O. STEPHENS (U.S. Geological Survey, Mania Park. CA 94052)

# Recent Microse isolcity Along the Eastern Gulf of Alaska and Its Molation to the Yakatega Seisaic Bap

L. U. SIEPPENS. J. C. LANR R. A. PAGE

(USGS, Manio Park, CA 94025)

Since 1974 the USGS has been monitoring seismicity along the eastern Guif of Alasta, an area that includes the Yakataga seismic gap which is considered to be a likely area for one or more large (A 7), inter-plate thrust earthquakes possibly within then meat two or three decades. In 1973, the St. Elias earthquake (A 7.), a low-angle thrust event, occurred at the eastern end of the gap. Apart from the aftershock activity of this marthquake, the spatial distribution of saismicity in and around the gap since the St. Elias earthquake has been rearrably similar to that observed prior to 1979. In a some extending about 80 to inland from the coast melacon Prince William Sound and Yakuta Bay the seismicity is characterized by proad concentrations of shellow (35 to depth) activity experated by regions of relative quiescence, within this zone the epicenters define 5-10 to patches earthquake, a diffuse pattern around Maxell Ridge near the center of the gap, and a Cluster of epiconters mear the mouth of the Cooper River Delta. North of the coastal zone a MAM. - to ESC.-treen of shallow activity punctuated by saai clusters of epicenters extends along the south flants of the Mrangell Lowes to the southeast end of the lists of the Mrangell Lowes to the southeast and of the lists of the Mrangell Lowes to the System, Concentrations of epicenters also occur offshare near the mostern end of the gap. A Muto-SE. trend of activity extending along the northwest carries of the Yakutat foreland may confirm the presence of a previously inferred fault. The St. Elias aftershock zone is one of the seast being maintaned where focal depths are sufficiently reliable to resolve dipping structure; in this area the hypocenters define a shallow, different the most one that the paper and lower took followed to the Madal Jules and Lower took followed to the Madal Jules and Lower took followed to the Madal Jules and Lower took followed to the season.

## Estinguaba Selection by the JND Method in the Andish Select and Lower Cook Color Areas of Alasha

H. FCERS (Geophysical Institute, University of Alaska, Fairtanks, Alaska 99701) C. FRORLEM (Institute for complicates, Univer-sity of Jezis, Austin, Josep 28712)

An adaptation for local network date of the Joint Hypocanter Datermination (JHD) method was used to elemitaneously relocate 243 selected earthquakes which were very well recorded by a regional selection network in the Kodiak laland-Alacha Pentasula and Dieor Cook Index of the Cook Index, the relocated events clearly define a IQ- to 20-km thick Bendolf sont dipping at an angle of about 49 degrees. Several well-located events like distinctly beneath the main some by about 15 to 20 km. There results agree well which those reported by Lahr (1973) for this area. In the Fodiak Island-Alacha Pentasula area, in the Fodiak Island-Alacha Pentasula area, in the Fodiak Island-Alacha Pentasula area, in the stdiak Island-Alacha Pentasula area, the Pentoff some dipp at about 40 degrees and there is approximately a 10-degree difference in the arrive direction of the Benjoff some between the two areads. Thirry-five aftershocks of the 19th Alacka earthquist-located with the JHD nethod, using telesticit date. The relocated spicanters lie along the shelf break in a ruch less diffuse cluster than the epicanters topoximally the ISC. The depths of six of the events were redetermined using depth phases. These excets define a narrow, gently dipping challow thrust sope.

# Progress Report on the Carthonake Prediction Effort at Elk Lake, Vashiorion

TENDY C. GRANT CRAG S. TRAVER (both U.S. Geological Survey, at Geo-physics Program, AX-50, Univ. of Wash., Seattle, WA 98195) BAYID FRANK (U. S. Gmological Survey, at Crological Sciences, Al-20 Univ. of Wash. Scalle, WA 88195) JAMES E. ZOLLWEG (Geophysics Program, AK-50 Univ. of Wash. Scattle, WA 99195)

The magnitude  $0.5~(H_L)$  earthquake that occurred on Fabruary 14. 1981 has Elk Lake. Wash, was the largest earthquake to occur in Yashington since the Seattle  $(H_1 \otimes 5)$  carthquake of 1985. Moreover, the Elk Lake earthquake is the largest moderate shellowers of the largest moderate shellowers in western Washington in recent heaters.

Aftershocks were still occurring from the Pebru-ery 1981 main shock in June, 1982. On March I, 1982, the largest (M<sub>1</sub> = 4.1) aftershock of the sequence occurred within a kilometer of the main shock but near the bottom of the zone of sheed by the previous aftershocks. Since this March I event, many af-sarhooks have been located to the deeper part of the same. The present rate of aftershock occurred. Arthouse neve been located to the compart part of the same. The present rate of aftershock occurrence is some to that before the magnitude 4.1 event; however, the number of M. 22 orants has increased

Ever, the number of M<sub>L</sub> 22 cents has increased. Due to the continuing aftershook estavity and the alignment of P-42s with models of on-going subduction in the Facilic Northwest, we believe that another or agnitude shallow earthquaks in this zone is likely accordingly, we have established a prediction program for the Zik Lake area. Radon emission has been monitored since number 1991. and three-component assumes raph stations are being intelled this summer in the aftershock zone to study spectra. P.S welcity and amplitude ratios are being monitored with the objective of establishing baselines before another large

fruit of facility with Aprican pines

J. v. Pavit, (Alaska Division of Geological and Geophysical Surreys, c/o Geophysical Institute, University of Alaska, Jaithonka, AE 93701)

in a secont paper. Nakamera and others suggest that neotertenic presse trajectories for interior flather can be deduced from the pattern of Aprincipal volcation and strike-size faulting. A principal stress trajectory takening the direction of maximum perfecting the compounding the direction of maximum perfecting in Frince Militan for that paper unightering in Frince Militan fault and the curving more westerly to Mome on the Several Faultain. To this paper it is noted that this trajectory is subpersiled with both the

northeastern edge of the Pacific Flate and, in interior Alaska, with the locus of all shallow (b 30 km) earthquakes of magnitude granter than aix. This coincidence leads to the spaculation that these interior Alaska sarthquakes are occurring along a principal slip-line resulting from the collision of the Pacific and North American Plates in the Gulf of Alaska region. Here the same analogy to a rigid indenter (Facific Plate) punching into an elastic/plastic massrial (Alaska) is used as sid Noiner and Tapponnier for the case of India colliding with Eurasia. It is not suggested that this elip-line represents a particular fault arcing through central Alaska; rather that it represents a catvillnear soms of high etress within which (sworably oriented, preculating faults are reactivated.

#### Volcanology

Upper Cretaceons - Lover Tertiary Volcanic Rooks

<u>PIANA M. SULEE</u> (Atters Division of Geological and Geophysical Surveys, College, AK 99708) THORMS K. BUNDIZEN (Alaska Division of Geo-logical and Geophysical Surveys, College, AK 99708) 99708) Wratt G. GILBERT (Alaska Division of Geologics) and Geophysical Survays, College, AK 99708)

and Geophysical Surveys, College, AK 99708)

Depar Cratacaeus to lower Tertlary volcanic rocks occur on the north side of the seuthern Alaska Sucque nor the north side of the seuthern Alaska Surgeys the Surveys reveals three ignous complexes, each composed predominantly of intermadists flows and dives, traffs of intermediate of elekt composition, and subordinats baseltic flows and dives that collectively cover an area of approximately 50 km². The volcanic and bypolyses rocks intrude and overlies a thick section of highly folded Paleonoic sediaentary and low-grade matemorphic rocks.

The Velenks Lake couplex consists of chloritized aphasitic to porphyro-sphanitic dacits flows intruded by numerous bornhleude granodiorite dikes. Kinor baselt flows and rhyolits tuffs are so present.

The Sheep Creek couplex contains locally porphyritic olivins-augite baselt flows internaly entermined the present of the Valence and tuffs and felsion to intermediate air-fall tuffs. Baccuse volumentically extensive granodiorics dikes anction—spungar age is suggested for this pile. The Windy Fork couplex concentric, andesitic dive suarsa and probably represents a sajor eruptive source for the Sheep Creek couplex to the sales.

Numerous at ructurally controlled dikes that cut the Faleonoic section tran horthest near Vindy Fork and northwest mar Valenka lake. The naguestur-from-alkail plot (APM disgram) and the wide range in chamical composition demonstrates a cale-alkalim trend for the volcanic suites.

In Fetrology, Geochemistry and Instance.

# Ine Petrology, Seochemistry and Isotope Seochronology of the Gilmore Nome and Pedro Dome Plutons Fairbanks District, Alaska

J. D. Blum (Mohawk Resources Alaske, Inc., P.O. Box 74224, Fairbanks, Alaska 99707) (Sponsor: S. E. Swanson)

(Sponsor: S. Swanson)

A knowledge of the oschemical and petrologic characteristics of the intrusive rocks in the Fairbanks district is important to our understanding of the ecologic history and mineral potential of the region. Intrusive rocks in the district occur mainly as northeast trending bodies ranging in composition from granoidorite to quartz wonzonite. Modal point. Count, major-oxide, and trace-element analysis indicate that the plutons represent a commentic fractionation swite and that the main mail radic rocks were explaced first, followed by procressively more felsic rocks. Comparison of splite dike compositions to the synthetic granite syciety wore felsic rocks. Comparison of splite dike compositions to the synthetic granite syciety yeld depth estimates of about 4 km. A Abys inochron yelded an age of 91.0 x 0.7 s.y. and previously determained K/Ar dates are provided to 1.0 x 0.7 s.y. which indicates that the rocks havenined to 1.0 x 0.7 s.y. which indicates that the rocks havenined to 1.0 x 0.7 s.y. which indicates that the rocks haven not undergone a thermal resetting of the K/Ar age. The initial 3/Sr/80Sr ratio is 0.71238 which rules out the rocks are brimarily derived from remelted recessary bring and the K/Ar age. The initial strong limit rodes for the magon and suggest that the rocks are brimarily derived from remelted recessary in crustal rocks. Petrologic considerations limit rodes for the origin of tungsten and ool enteratization located near the intrusive contacts. The patals were alther remobilized from the surrounding schitts and concentrated near intrusive contacts because the contacts provided one intensity enters and reconcentrated during the crystallization of the magma.

#### Igueous Petrology and Geochtmistry of Borthern Ahutan Jaland, Alaska

J. D. ROWICE (Aleska Division of Geological and Geophysical Survey, College, AK 99708; Geology/Geophysics Program, University of Alaska, Fairbanks, AZ 99701) (Sponsor: S. E. Swenson)

Abuten Island is a relactively unstudied inland located in the eastern Alautian Arc. Abutan lavag are tholetitic and range between 46 and 63 percent \$102, with FeO4/AgO racios between 1.3 and 4.2. Two petrologic groups are recognized; olivine-climpyrozene baselts from wastern Abutan Island, and elinopytoxens-orthopytoxens andesites exposed elsowhere on the island. The two groups are distinguished chemically by lower Bb (less than 23 ppm) and bigher Sr (greater thus 400 ppm) abundances in the olivingclimpyroxene baselts. R-Ar whole cock dates Indicate that leve flows from both groups erupted between 1.4 and 1.1 million years ago. Climpyrozene, orthopyrozene, and ollwine compositions are uniform across the island, and average Ca45 Me42 Pe17 Si206. Me66 Pe34 Si0, and May 2 For 28 Signature Playloriane composition varies between Angs and Angs.

The two laws types may be the result of shellowteral fractionation and subsequent stuption from

different levels of a soned magan chamber. Volcanism, Seismicity and Plate Subduction in The tastern Algulian Arc

JURGEN KIEME SABULL E. SWARSON (both at: Geophysical Institute, University of Alasta, Fairbanks, AK 99701) University of Alaska, Fairbarks, AK 99701)

Volcanism in the eastern Aleutian arc is the result of near normal convergence of the Pacific and American pitals. Minateen volcanic canters lie between Kejulik and Hayes Volcanoes, which cano spacing, Volcanoes of differing trend and voltages and the Volcanoes of the 115 km long Kaisal separat (Kajulik to Davils Desk) are closely special (11 36 km) and strike # 55° E, while volcanoes of the 110 km long Cook Inlet separat & km apart. Kepsyak Calders & the pivol point between the 2 Secuents.

The geometry of the Benioff zone in Kaisal and Cook Inlet has been defined by exchanges data from a high-gain, short-period selscoprophy naturers. The Benioff zone dips at 45° beneath the

volcanic arc and extends to 200 km. The sharp is misalignment of the katmai and fook injet solcanes is mimicked by the subducting plate which does strike more northerly in Cook injet, resulting in a 35° divergence of plate plungs and plate convergence, but the lateral warping of the subducting plate occurs smoothly and we have not found any setsmic evidence for hinge or tear faulting near the pivot point of valcanic misalignment at Kaguyak Caidora.

Regular, wide spacing of volcanic conters in Cook Injet and fairly close alignment of valcanes over the 100 km depth contour to the Denitoff size suggest that dispiric rise of mantle plumes from a gravitationally unstable narrow mantle source region controls the location of these volcanes. Much closer volcane spacing, misorientation of the valcanic front with respect to the strike of the Benioff zone, strong tectoric control of volcane alignment and a tendency toward core evolved lavas and caldera formation in Katmai may be the result of lateral leakage and storage of magna along crustal fractures as deeply rooted mintle dispirs reach shallow crust.

Petrology and Segmentation in the Factors

### Petrology and Segmentation in the Fastern Aleutian Arc

SAMUEL E. SWAMSON
JURNER KIEMLE (Both at: Geophysical Institute,
University of Alaska, Fairbanks, AK 99701)

University of Alaska, Fairbanks, Ak 99701)

The astern Aleutian volcanic arc can be divided into two major sequents hased upon volcanic alignment and volcano spacing, which we call the Cook injet and the katmal segments. Lavas in the eastern Alautien Arc are Calcalkaling and dominantly two-pyrosene andesite with minor decite and basalt. Rhypitile is found at Mt. Katmal and Royarupta. Major element chanical data suggest the Katmal lavas are richer in silica (SiO2 avg. 62%) than the Cook Injet lavas (SiO2 avg. 62%) than the Cook Injet lavas (SiO2 avg. 59%). Katmal lavas also contain more potassium than the Cook Injet lavas (K60 \* 1.42 for Katmal, 1.12 for Cook Injet lavas (K60 \* 1.42 for Katmal, 1.12 for Cook Injet lavas are mainly composed of decite with minor andesite. Hornblende-bearing quartz dacite, an unusual rock in the eastern Aleutian lavas, is the most doundant lithology. Chemically, Kaquyak lavas show calcalkaling fractionation (SiO2 - 59-66%, FaO/MgO = 1.5-3.1) in contrast to other segment boundary volcanoes in the Aleutian arc that show tholelitic differentiation. Katmal volcanoes are aligned along the crest of an anticline in the Mesozoic basement rocks while the Cook inlet volcanoes show no apparent relation to crustal structures. This shallow-level structural control may promote low pressure fractionation thus explaining the more evolved character of the Katmal lavas. Calcalkaline magmals at Keguyak Crater may also be related to shallow-level fractionation.

# Yolcanic Earthquakes, and the Precursors in the 1981 Eruptions of Wount St. Helens

Staphan D. Halone Christina Boyko (Both at Geophyaics Prog., Univ. of Mash., Seattle, WA 98193)

Saismograms for seismic events recorded at Mount St. Helens are classified into 4 major types based on their character. I) Deep sartiquekes and those located every from the volcano have high frequency impulsive arrivals saidlish to fectoric earthquekes and are not directly related to equitions. 2) Earthquekes located at depths less than Sun, under the lave does have saidles to low frequency arrivals and occur in increasing numbers prior to eruptions. 3) Surface events such as rock-tails and energetic gas bursts from the does have estingent, complicated seismograms with no clear beginning or end, and occur in great numbers during and following eruptions. 4) Hareonic tresor is continuous monochromatic signed which may last from sinutes to hours and is often essociated with eruptive activity or at least small ges emissions. Temporal changes in the energy release of the lost fraquexcy earthquekes (type 2 events) has been used to help forecast the last nine eruptions. The data indicate that both the propagation path and the source time function play laportent roles in the character of the selemograms. Without a detailed knowledge of the velocity structure, determining the relative importance of these two factors is nearly impossible.

# leep Earthquakes and Possible Masmalle Lee Transport at Mount at Holons, Tashing-

CRAIG S. WEAVER
(U.S. Geological Survey, at Geophysics Program, AK-50, Univ. of Wash., Seattle, WA 98195)
JAMES E. ZOLIWEG (Geophysics Program, AK-50, Univ. of Wash. Seattle, WA 98196)

Small magnitude sarthquakes began bonnath Mount St. Helens, Wash., 41 days before the March 20, 1982 sruption. Two aspects of this pre-pruption solumidity indicate that this sequence differed from chier dome-building sruptions. First, a significant than the shallow (c3 km) earthquakes were desper (b-11 km) of all previous dome-building sruptions. Second, the lorense in seismicity occurred well before changes in surface deformation measured near the order than doms. Statistically significant deformation was not measured until March 11, 32 days after the seismicity began.

began. The time-depth distribution of earthquake activity. The time-depth distribution of earthquake activity shows two periods that are consistent with the upward migration of a magmatic fluid, most likely gas. First, migrated showr interval on March 3, bypocenters at an everage rate of more than 500 m/b. Sacond, the last of the well-located deep earthquakes occurred on March 12 at depths of 6 km, and 4 hours after these quakes occurred. The rapid increase in surface deformation after March 11 and the targe amount of esteroic macray released in shellow earthquakes in the hours have released to March 20 are size occurred. The control of the small explosion that initiated postulated magmatic gas transport hypothesis.

The deep carthquakes in this presenting

The deep earthquakes in this pre-sruption is equence are important because they suggest that a larger volume of the magmatic system was involved in the March 20 eruption than in any eruption since the explosive gruptions in summer, 1980.

# Comparison of Synthetic and Observed Seismograms Ler Volcanic tarthquakes at Augustine Volcano DOUBLAS J. LALLA JUENGER RIERE (Both at: Geophysica) Institute, University of Alaska, Fairbanks, AK 99701)

University of Alaska, Fairbanks, Ak 99701)

Volcanic earthquakes recorded on a 5-station short-period saismic array located on Augustine from station to station. The provided saismic array located on Augustine from station to station. The samplitude variations are also strongly dependent on source location. The purpose of this study is to investigate whether or not the amplitude variations can be explained by a heterogeneous velocity structure of the volcano. This structure variations can be explained by a heterogeneous velocity structure of the volcano. This structure was previously developed from the amplying of travel time date from 10 explosive charges that were set off on the volcano in 1978.

A preliminary 2-D daussian hear computer program developed by Ennect (HIT) lasted on the method developed by Ennect (HIT) lasted on the method developed by Ennect (HIT) lasted on the method injuristry. Fragus, 1981) was used in the analysis. Velocity structure aperpendicular to the 2-D calculations. Frae surface effects are not using the Gaussian beam pethod. In general, the previously determined heterogeneous velocity structure does explain the observed differences. In detail, fectsing of metanic rays

is estrice, implying that saleanic structures of even molerate complexity will produce complexed amplitude sariations at surface stations due to the strong contrast of high selectly igneous and entrusive holies, such as central vent complexes, downs, sills, dives and law flows, with low selectly interfedded and overlying proclastic deposits. Ray-tracing models and synthetic setue, grans illustrating these effects will be discussed.

Breent Serimicity dround spair Bedoubt, and R. A. PAIR, J. A. MALLEN, C. D. STEPHENS (USSS, Mento Park, CA 94025)

bur the past decade, the U.S. Geological Survey regional sets-syraph network in Southern Alaska has been recording small shallow-focus earlinguates around the active valcaness-Spern, secoud, and Illamia-mest of Cook Inlet, because of their mail size, for of the shock haso been routlinely located. Recently, however, efforts have been undertaken to locate these excits.

have been routinely located. Recently, however, efforts have been undertaken to locate these chois.

Locations have been determined for 110 shallow (S-P interval - 5 sec) carthquakes in the magnitude range side to care better 10 chose 1980 and 10 done 1981. Re significant volcanic activity was reported for this time, and no pronounced earthquake small was observed near any volcand. Five shocks shallower than 10 km deep occurred within an enfocuted idistance of 3 km or sport; to shocks described a diffuse pattern within 50 km of fledubit; and 2 events occurred within 50 km of fledubit; and 2 events occurred within 50 km of fliames. Elsewhere, notable concentrations of chicenters were located 13 km south of sport mear the Chight Houston May, for fusedni Bay and in the Chight Houston wast of fusedni Bay and in the Chight Houston wast of 1982, more than 180 shallow shocks smaller than Gapair to 3 seconds within 5 km of Sport small, Most of these events belonged to an intured warm of aerthquakes shaller than HO that occurred at the one of the first quarter of 1982, more than 190 shallow shocks smaller than HO that occurred at the one of the first quarter of seconds warm of aerthquakes shaller than HO that occurred at the one of the forest (-5 km) to the site of the 1951 sport empty on. They appear to originate at shallow depth near the station but whether they result from volcanic processes or surficial processes, such as avalanching or glacial movement, is unresolved.

# Fluctuations in Heat Flow from the North Crater, Mt. Prangell, Alacks

R. J. BOTYKA (AK DIV. of ocological and Geophysical Surveys, P.O. Sox sunor), College, AK 99708; C. S. BERSON (Geophysical Intitude, University of Alaska, Fairhanka, AK 99708)

of Alaska, Fairhamba, ak 1970s)

Buginning in 17th thermal activity has increased dramitically in the North Crater, one of three traces activity in the North Crater, one of three traces activity in the North Crater, one of three traces activity of the presence of glacier for within the Borth Crater provided a means of monitoring the changes in heat flow with time through glacier colorises try. Since 1906 heat flow in teccovered are noted the crater has followed a variable pottern of activity with peaks occurring in 1908, 1974, and 1909. The onset of a thermal point is characterized by a rapid increase in heat flow over two-veat period. Best flux during the 1975-72 peak in activity was at least 50 MM, an entimated by a laster colorisater; 20 times the cultivated pre-1905 heat flow it Rorth Crater. The peaks in activity have been followed by a lower-year diction in heat flow for glacial movered areas and by internee in toe free regions as well. The chetty released during periods of increasing activity bus algufficantly increased with each not contribute pulse of activity with the increase meeting activity bus algufficantly increased with each more contributive in algufficantly increased with each more contributed and increasing activity bus algufficantly increased with each more contributive in algufficantly increased with each more contributed by the summer of functions appear to be superiopeced on a lenger term trong of increasing heat flow. The analyse factivity with the increase account in the term point and 1880, By 1980 ever 800 of the oil pinal 17th worked of the withing of the within of the within of the crater had continued increasing rather than decilining. This ampoints that the volume of self-wither being pomerated is no longer sufficient to quoue had helder.

# 40Ar/3ºAr Ages of Columbia Rivor Basalt From Ocop Burcholes in South-Central Washington

P, E. LONG (Boselt Wasto Isolation Project, Rockwoll Hanford Operations, Richland, WA

99352) R. A. DUNCAN (School of Oceanography, Oragon State University, Corvallis, OR 97331)

Stata University, Corvallis, OR 97331)

\*\*OAr/1\*Ar age spectrums have been obtained by incremental heating experiments for eight wholstock samples of Columbia River leastl from doep borsholds in south-contral Washington. The samples analyzed bracket major stratigraphic horizons within the Grande Ronde Rasalt (RRS) portion of the Columbia River Basalt Group, including the Vantage horizon, the Mg horizon, and the Ms-R, paleomagnatic horizon. Diffusive loss of radiagonic Ar has occurred in most samples, but reliable crystallization ages are apparently preserved in the higher temperature gas increments. Dost estimates of crystallization ages for six QRB samples from core well loc-12 range from 15.6 to 16.1 m.y. (90.2 m.y., 10.). Stratigraphic considerations suggest that the age of fiference between the Nz-Rz paleomagnetic horizon and the Vantage horizon tenderation within the resolution of the technique. We therefore conclude that this sequence of 15 GRB flows was deposited in \*600.000 years. The age of the Vantage horizon is estimated to be 15.6 10.2 m.y. or -1 m.y. greater than estimates based on conventional k.-Ar techniques.

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#### Aeronomy

0410 Absorption and scattering of radiation (particles

0-10 Absorption and scattering of radiation (particles or waves)
THE PELTA BAND DISSOCIATION OF NITRIC OXIDE: A
POTENTIAL MECHANISM FOR COUPLING THERMOSPHERE
VARIATIONS TO THE MESOSPHERE AND STRATOSPHERE
J. E. Frederick (MESA/Goddard Space Flight Center,
Code 964, Greenbelt, Maryland, 20771), F. B. Abrams
and P. J. Crutzen
Depletion of solar radiation at discrete wavelengths
by nitric oxide has a significant impact on the dissoclation rate of this gas in the d(0,0) and d(1,0)
hands. Inclusion of the opacity provided by a typical
MO profile raduces the dissociation rate in the upper
stratosphere to 50-70% of that predicted when the
optical depth celculation omits this contribution. A
substantial fraction of the nitric oxide column shundance as smasured near the stratopause resides in the
lower thermosphere where correlations of KO with solar
and magnetic activity are well documented. Variations
in the thermosphere where correlations of KO with solar
and magnetic activity are well documented. Variations
in the thermosphere where correlations of KO with solar
and magnetic activity are well documented. Variations
the radiation field at the procise wavelengths absorbed
by this molecule in the mesosphere and upper stratosphere providing a direct and instantaneous coupling
betteen the different altitude regions.
J. Geophys. Rea., Green, Paper 300130

0450 Density Intial Teats of an index based on al values for Modeling Magnetic Storm Related Perturbations of the

INITIAL TESTS OF AN INDEX HASED ON AL VALUES FOR MODELING MAGNETIC STORM RELATED PERTURENTIONS OF THE THERMOSPHERR John S. Nisbet, (Ionosphere Research Laboratory, Department of Electrical Engineering, The Pennsylvania State University, University Park, Pennsylvania 16802), Carl Stehle, and Ernst Bleuler Very Large perturbations in the thermosphere and ionosphere are induced by motions driven by heating and by electric fields in the auroral electroler regions. Winds carry these effects to all lacticudes. Because of this, thermospheric models have terms associated with magnetic activity. The Ry and Ap indices have usually bean amployed however, these are poorly correlated with the temporal variations. Initial experiments are described with new indices based on the surroral siletrojet indices over a period rather then on instantaneous values. Comparisons are made with the 2-hour ap index for high-lacticude atomic expenses are drawn on the problems and promise of the auroral electrojet indices over a period rather than on instantaneous values. Comparisons are made with the 3-hour ap index for high-lacticude atomic expenses are drawn on the problems and promise of the approach. (Thermosphere, altonic caygen, magnetic storms, current alsortrojet index).

J. Geophya, Res., Blug, Paper 2A1983 J. Geophys. Res., Blue, Paper 2A1983

#### Electromagnetics

Electromagnetics

O'80 Scattering
LATITUDINAL AND MAGNETIC FLUX TUBE EXTENSION OF THE
EQUATORIAL SPRAID F TRREGULARITIES

M. A. Abd Wilself Luce of Penguines Expecisis, Consolho
Macional de Desanvolvienne Cientifico o Tounológico,
1200, 850 José dos Campos, SP, Brasili, R. T. da

A comparative atudy has been carried out of the spread
F occurrence characteristica at the magnetic equatorisi
thation, Portalesa (408, 1809, dip latitude 1.89s) and
the low latitude station, Cachesira Paulista (208,
4598, dip latitude 1409) located with a relatively small
lengitudinal differance, in Result. The results show
strong correlation between the occurrence of spread F
avonts at the two stations for mour of the time. Mail
all the spread F avents over Cachesira Paulista are
is not true. Also the spread F onest times over the
latitude. Another interesting result is that while the
spread F durations at the two stations are approximately
linearly related, an awent over Cachesira Paulista is
ches equator and profice the spreading control of the squatorial input appears to have peaked
time trim the case of the time and the forest-soli input. The forest-soil input. The forest-

0799 Ceneral (Numerical Mathods)
RUMRRICAL GALGULATIONS OF LOW-FREQUENCY IN FIELDS IN ARBITRARIA SHAPED LOSS DELECTRIC CYLENDRES

G. Hill (Slear-tical Enginearing Department, University of Utah, Sait Lake City, Utah 86112), G. H.

Durmay, and D. A. Christenman

The Galerkin method with subsectional linear basis and velighting functions is used to calculate the lowfrequency transverse electric fields in lossy delectric cylinders. Arbitrarily shaped polygonal units are 
employed to allow more accurate modelling of complex 
the validity of the method, the analytical and memorical solutions are compared for triple-layered concentric cylinders. The calculated fields in a model of 
the human torus exposed to a solunoidal field sra size 
presented. Among other applications, the method should 
be useful for evaluating electromagnetic (EM) blohasaced, and for malyning and designing disjectric entandes and hypertharmia applicators at low frequencies.

Rad. Sci., Paper 380177

Geomagnetism and 
Cacumagnetism and 
Paleomagnetism

D. I. GCUSI (Institute of Earth and F

University of Alberts, Edmonton, a 
TGG. 231)

N. R. DNGRM (Department of Physics, 
alty of Wallington, Private Beg, W

Zealand)

Th recent years, interpretation and 
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O.365 near the main heat transfer stone of the gac-thermal reservoir. The dynamic shear and Young's modulus are significantly lower near the principal heat transfer surfaces but the bulk modulus is largely unaffected. Those observations suggest that the velocity differences are caused by fully saturated fractures. We demonstrate that the fractures inforred by this survey may have lengths as large as 70 cm. These fractures may have lengths as large as 70 cm. These fractures may have been caused by shear failure, microgracking associated with thermal drawdown or thermal stress oracking.

#### Geochemistry

Geochemistry

1410 Chamistry of the atmosphere
PRECIPITATION CHEMISTRY AT THE MARCELL EXPERIMENTAL
POREST IN MORTH CENTRAL MINNESOYA

Blon S. Verry (U.S. Department of Agriculture, Forest
Service, North Central Porest Experiment Station, Grand
Rapids, Minnesots, 15744)

Concentration (ug and minroeq./I) values are
presented for unjor ions occurring to trin and snow
from July, 1978 to July, 1980. Amontum, modium,
and calcion are the largest equivalent weight
cations which are largely belanced by sulfate and
nitrate andone. Rivingen is the fourth most
abundant cations, but high combined concentrations
of other cations in 27 percent of the sample events
mask positive correlations with high bylrogen
concentrations. Field-measured PR swraged 4.3,
but fluctuated within the tange (1.5 to 6.5) with
earth and air mass conditions. When high cation
(and anion) date are deleted, lov pit correlates
well with high stirate. Sulfate concentrations are
statiar to those measured in 1936 and do not
correlate with pit. Calcium and, to a lesser extent,
ammontum tand to increase pit values. High attrace
values also correlate positively with high excess
acidity; while high sedim and calcium values
correlate with high stim and calcium values
correlates with high sedim and calcium values.

# 1410 Chemiatry of the atmosphere THE GLOBAL DISTRIBUTION OF ATMOSPHERIC CAPBON DICKIDS. II. A REVIEW OF PROVISIONAL BACKGROUND OBSERVATIONS, 1078-1307

THE GLOBAL DISTRIBUTION OF ATMOSPHERIC CAPBON DIOXIDS.

17. A REVIEW OF PROVISIONAL BACKGROUND OBSERVATIONS,

1978-1980.

P.J. Fraser (CSIRO Division of Almospheric Physics,
Aspendale, Victoria 1981, G.1 Pearsan end P. Ryson.
An attempt is made to bring together provisional data
collected throughout the world to construct a global
picture of the beokground atmospheric carbon dioxide
concentration distribution. The uncertainties, calibration and sampling difficulties, and measurement needs
are discussed and it is concluded that in general the
accuracy of the provisional data at each sampling
location is "11 pear. On-going studies at the nain
laboratories are likely to significantly improve this
accuracy in the near future.

The most recent data available (for 1980) indicates
annual average northern homisphers high latitude CO,
concentrations 4 to 5 year above those at high latitudes
of the southern hemisphers (-136 ppws). The greatest
uncertainty in the sonal ayerage concentration exists
in the latitude bend 10-30°s where surface observations
are 2-1 ppws higher than those measured by continuous
analysis at the Manua Los Observatory. There is
generally good agreement between a model-generated and
the observed annual man global distributions.

The rotal global atmospheric CO, content, averaged

6 ppsw at 20°M and '15 ppsw at high latitudes of the northern homisphere. The total global atmospheric CO, content, averaged through 1900, is estimated to have been 7.15 x 10<sup>1</sup>m and the potable uncertainty of 0.5 to 1.04. (Carbon with a probable uncertainty of 0.5 to 1.04. (Carbon dioxide, atmospheric monitoring). J. Geophys. Res., Green, Paper 300115

1410 Chamistry of the Atmosphere

A DECONVOLUTION OF THE TREE SLAW BASED 6<sup>13</sup>C RECORD

T.-H. Poly (AM. P.1) & Read and I to, A.2 Pille...

Tonnessee, 18300, W. S. Broocker, H. D. Freyer, and

S. Trumbore

A composite record of <sup>13</sup>C/<sup>12</sup>C for the last 150 years has been constructed for the cellulose from open site trace. Using an Oschgar-type ocean model this record has been deconvolved to yield the anthropogenic CO, input over that time period. The known fossil fuel input shaw hean subtracted from this input yielding an ostimate for the format and soil component. This smalysle yields a total input via forest and soils somewhat greater them that via fossil fuels. However during the last 20 year time period for which an atmospheric CO, record is available the fossil fuel input has been shout five times greater than the forest-soil input, the forest-soil input appears to have peaked close to the turn of the century and has been declining toward the presence, Because of this decline the change in atmospheric CO, contain over the last 20 years attributable to forest and soil inputs has been quite small. However because of the remaining questions about the validity of the "C racord derived from the studies of tree rings our analysis has to be taken more as an example of the power of the "C approach than as a firm

.990 Instruments and techniques
itRBORNE GRAVITY IS ERRE
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itERORNE GRAVITY IS ERRE
The achievement of practical and useful sirborus
gravity exploration for petroleum is a major
culmination of more than twenty years of reasarch and
development. Generatial surveys have now been conducted
for three years. The precision and anomaly resolution
attainable are twice as good as that of current
shipborus gravity data. This paper presents date to
demonstrate the precision of sirborus gravity and
discusses its usefulness (with simultaneous magnetics
and topography). Industrial acceptance of the method
portends a new era in gaophysical exploration for oil
and gas which gives premise to double the effectiveness
of explorations on land in both time and cost.
GEOPHYSICS, VOL. 48, NO. 2

Interpretation dethods for Magn.scommeter Arrays D. I. GCUST (Institute of Earth and Planetary Physics, University of Alberta, Edmonton, Alberta, Canada 16G 2J1) M. R. INGRAM (Department of Physics, Victoria Univer-sity of Wallington, Private Beg, Wallington, New Zealand)

the human torse apposed to a soluncidal field are also presented. Among other applications, the method should be useful for evaluating electromagnatic (EM) blohastade, and for enalyzing and designing dislectric antendes and hypertherais applicators at low frequencies.

Exploration Geophysics

Cxploration Geophysics

Cxploration Rethods

CRIMORS IN COUNTRESIDENT AND SHEAR WAYE VELOCITIES AND DEATED HOULD DURING OPERATION OF A NOT DRY BOOK Division, local Aleance Rational Laboratory, Loc Aleance, and these wave velocities measured during oross will selacing correspond and above wave velocities measured during oross will selacing our velocity increases during oross will selacing our velocity degrees the relative F- and S-wave velocity degrees and in the relative f- and should be designed by O'Connell and containing fluid-seturated and dry grands. Recourse filled frequences to an increased density of Turis filled frequence to the reservoir. Frequency as high as conditions maked and should be added to the containing fluid-seturated and dry grands. Recourse filled frequences to an increased density of Turis filled frequences to an increased density of Turis filled frequences to an increased density of Turis filled frequences to the reservoir. Frequence density of Turis filled frequences to the reservoir. Frequence density of Turis days and substances and the services of O'Connell and Spalensky resign as high as and substances of the containing filled frequences to the reservoir. Frequence density of Turis days and substances and the services of the reservoir. Frequence density of Turis days and substances and the services of the reservoir. Frequence density of Turis days and substances and the services of the reservoir. Frequence density of Turis days and the paper and substances for the produced produced the services of the reservoir. Frequence density of Turis days and the paper and substances for the produced produced the filling and transfer functions.

2560 PALEDMAGNETI

PALEOMAGNETISM
PALEOMAGNETISM OF A POLARITY TRANSITION. WINNER
LOURE (1) TRIABSIC CHUGMATER FORMATON. WINNER
E. Represo-Betwere (Bawaii Institute of
Geophysics, 2225 Corres Road, Homolulu, Hawaii,
98522) and C. E. Heisley
A total of 136 oriented specimens, taken at
atratigraphic intorvats of 3 to 20 cm, have been
collected from the Red Peak Hember of the
Chugware Forestion at three localities
approximately 25 km southeast of Dubois,
Wyoning. The stratigraphic interval containing
the polarity transition in the remanent uniquestic
field is about 1.0 m. All specimens were
thermally desegnatized at 300°, 550°, 620°, and
650°G and show directions of segnetization of
morual, reversed and transitional character as
well as a reanstable decrease in the remanent
intensity in the transition some. The section
ampled is divided into five intensity periods:
two periods recording the dipolar field one
recording a dipolar field of decreasing
intensity; one recording a dipolar field or
increasing intensity; and a period of low
intensity; cone recording a dipolar field or
increasing intensity; and a period of low
intensity; cone recording the field present during the
180° directional swing. A VCP path obtained for
a N - R polarity transition makes a fairly
smooth transit, with the path confined to a
sector of longitude between 85°V to 110°R. The
reversal's ones is first indicated by a slow
movement of the VCP across corthern latitudes.
The VCP then lingers to two positions 60°N and
40°Y (33° to 70°C), and 20° and 40°N (335°E to
5°C), suggesting brist periods of field
stability for wondipolar field dominance). The
onast of the transition appears to be wore repid
than the recovery. The VCP path observed at a
morthern bemisphere site is located about 90°
from the site. The pole position derived from
atable normal and reversed portions of this
study (115.5°C, 46.6°N og., 40.1, 40 = 2.2,
dn = 4.2) lies approximately in the center of
the main group of poles reported for other
Triassic units. (Polarity transition, intensity
decreases,

#### Hydrology

J. Geophys. Pcs., PcJ, Paper 281954

3110 Erosion and Sedimentation
BAR RESISTANCE IN GRAYEL-BED STREARS AT BANKFULL STAGE
K. L. Prestepard (Lepartment of Geology, Franklin and
Marshall College, Box 3003, Lancaster PA 17604)
Total flow resistance in grevel-bed streams, with
high width/depth ratios and low sinussities, is
primarily a result of grain and bar roughnesses. The
relative importance of these two roughnesses. The
relative importance of these two roughnesses. The
relative importance of sealing for twelve
straight and divided gravel-bed reaches at bankfull
stage by using the Roulegan equation to determine a
resistance division of energy slope. The remaining
slope is assumed to represent the relative importance
of bar resistance. Bar resistance accounts for 50 to
75 percent of the total resistance in these reaches.
Calculated values of reach-averaged bar slope correlate
closely with field measurements of bar magnitude
Mator Pasour. Ren., Paper 200103

3110 Erosion and sodimentation
LAND USE, FLOODS, AND CHANNEL GHANGES: UPPER MIDDLE
FOR VILLAMETTE RIVER, ORDERN (1936-80)
Joseph N. Lyons (Unah Division of Oil, Cas and Hining,
424: State Office Building, Sait Lake City, Utah
841(4), Robert L. Boschts
Flow trends and charmel characteristics from 1936 to
1980 were evaluated for the Middle Fork Willametre
River, which drains a 668 km² formated watershed in
the Cascade Mountains of wastern Oregon. An inventory
of sarial photographs from 1939 to 1972 shows that
landslides associated with roads and in clearcuts were
2/ and 2) thase one impact, respectively, than in landelides associated with treads and in observate were 1/2 and 2) thats unto the them. I respectively, than in forested areas. Americas landelides unloaded sediments directly into the drainage system; most landelides appear to have been initiated during a large flood (return period 2 100 years) of bucember 22, 1964. Analysis of precipitation and peak flows (greens than 100 s<sup>3</sup> = 1) from 1958 to 1950 by means of power function models suggests a trend of increasing flows as tisker harvoating and road building expanded in the basio. Changes in channel pattern, documented from serial photographs, show major increases in charmel with from 1959 to 1967 and a trend of decreasing width from 1956 to 1960. Slicty-five cross sections of the channel were surveyed during summar low flows in 1979 and 1980 to provide detailed measurements of estating channel conditions. Chammel widths of 622 of the appraidad reaches were significantly greater (a = 0.05) than those for nonaggraidad reaches. (Channel works.)

Vater Resour. Res., Paper 190011

3130 Groundwater optimization of droundwater abstraction from a

OPTIMIZATION OF GROUNDWATER ARGITACTION FROM A COASTAL AGUIFAR E.H. Moral (Burmah Gil Exploration Ltd., Pipare Way, Svindon, Mileshire SB3 (RE, CE) and A.B. Rivties

An analytical unthemetical model, based on Jacobian elliptic functions, has been used to identify Feasible velifield locations and pumping rates for large-scale abstraction from an uncoafined constal equifer. The choice of optimum feasible velifield strategy has been used using a simple sconomic model which calculates the cost

of the pipelines required to transport the abstracted groundwater to a large coastal city which forms the demand centro. Results indicate that the cheapast wellfield design would be a single large wellfield. Revere, because of the used to maintain at least a minimum supply in the city until a new surface water source is developed developed, a better solution say well be to develop two smaller wellfields pusping a greater total abstraction. (Groundwater, abstraction, aquifer, coastal)

Rydrological Sciences J, vol. 28, no. 1.

Sydrological Sciences J. vol. 28, no. 1.

3130 Groundwater
SOME FROBLESS RELATING TO GROUNDWAVER BALASCE
I. Kayane (Institute of Geossiences, University
of Tsukuba, Daraki 309, Japan)
The groundwater balance for the city of Hegacha,
Japan, is promented an a case study. At Hegacha,
Japan, is promented an a case study. At Hegacha
where are thron interesting features: (a) in
viater groundwater is ejected from pipes under
the roads to well freshly fallen snow, (b) the
river is hydraulically in contact with the
aquifers, (c) the water table has remained quasistationary for the leat five years despite the
veat pumping programs. The main sources of
recharge are: the River Chinano, deep percolation
from irrigated fields, anougalt in spring, and
reinfall throughout the year. The water table
vas monitored using observation data from about
200 vella; daring the irrigation period in August
there was an inflow of groundwater, but groundwater resources were depleted in vitter and
apring by pumping for the snowesting scheme.
The evaluation and estimation of the components
of the groundwater balance are discussed; in
particular methods of measuring deep percolation
sliker directly or indirectly are aranimed.
(Groundwater balance, vater table, recharge, deep
percolation)
Sydrological Sciences J. vol. 28, no. 1. percolation)
Sydrological Sciences J. vol. 28, no. 1.

PLIO Groundwater
ANALYSIS OF AN IKCONGRUITY IN THE STANDARD GALERKIN
FIRITE-ELEMENT MUTHOD
R. L. Cooley (Water Resources Division, U.S. Geological
Survey, P.O. Box 25046, NS 413, Federal Center,
Labowood, Colorado B0225)
In the standard Galerkin finite-element method
spained to neutrinos of groundwater files about

In the standard Galerkin finite-element method applied to equations of ground-water flow, the development to incorporate second and third type boundary conditions implicitly assumes that the besis functions satisfy these boundary conditions. Because the heafs functions normally employed are not required to satisfy these boundary conditions, a theoretical incongruity is created. If the Galerkin procedure is reformulated by adding a term to explicitly consider failure of the besis functions to satisfy the boundary conditions, the incongruity is sliminated; however, the resulting set of operational equations is unchanged from the set resulting from applying the boundary conditions in the normal manner. As smallysts demonstrates that if the differential equation has a varietional equivalent, the same error functional is ninimized, whether or not the basis functions satisfy second and third type boundary conditions. (Groundwater Flow Models, Finite Flement Analysis, Calerkin Nathod).

Mater Resour. Rea. Paper 201943

Water Reacur, Rea., Paper 2M1943

3130 Groundwater
CROUND-WATER GROCKHISTRY AND CALCITE CEMESTATION
OF THE AGULE ACCITES IN SOUTHERN HAPPIAND
Francis B. Chapelle \*U.S. Ceological Survey.
208 Carroll Building, Some Issails Road.
Toseon, Maryland 21206)

The Aquia aquifer in southern Maryland exhibits
three regions that are characterized by distinctly
different water composition. Region I is about 76
miles wide and is parallel to the outcrop area.
Water in Region I has relatively high calcium
(\*\*\*Oo ng/L), magnesium (\*\*\*Oo ng/L), bicarbonate
(\*\*\*Oo ng/L), magnesium (\*\*\*Oo ng/L), bicarbonate
(\*\*\*Oo ng/L), includentations, and relatively beautiful to and demarations. Region II;
parallel to and demarations from Fegion I, is
about 2\*\* miles wide. Water in Region II;
parallel to and demarations hisarbonate, increasing
sodium, decreasing calcium and decreasing magnosium
concentrations. Region III is downgradient from
Region II and is characterized by low calcium
(\*\*\*Z ng/L), low magnosium (\*\*\*Z ng/L), high bicerbonate
(\*\*\*Z ng/L), low magnosium (\*\*\*Z ng/L), high bicerbonate
(\*\*Z ng/L), low magnosium
(\*\*Z ng/L), low magnosium
(\*\*Z ng/L), low

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instability and mon-uniqueness is controlled by reparameterisation utilizing the technique of finite elecents.
A set of statistics are developed to emplicitly quentify
the trade-off between the system modeling error and the
error associated with the parameter uncertainty. These
two types of errors are shown to be a function of the
parameter dimension. Remiduel mean square and trace of
the covariance metrix of two estimated parameters serve
as good indicators for the determination of the optime
year-motor dimension. A set of mosefuel experiments
are conducted to like attention to of the optime
year-motor dimension. A set of mosefuel experiments
are conducted to like attention to makedology.

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Lister Resour. Rea., Paper 18(18)

JIJO Croundwater

ANALTICAL SOLUTION OF A PARTIALLY FINITRATING

MELL IS A TNO-LAWER AUSSTR.

I. Javanial (Earth Science Division, Leoragem
Berhaley Laboratory, University of California,
Berkelay, Galifornia 94720), P. A. Wither spoon

The behavior of a Luo-layer aduler guaped by
a partially sensitating well is a matter of comalderable interest. Analytical solutions are
developed for drawlowns in after layer and are
evaluated numerically to illustrate sone typical
cases. The validity of the solutions is demonstrated by comparison with the limiting simple-layer
cases and with results from finite-element calculacious. Asymptotic polutions for small end intge
values of time are developed to show that (1) at
early times with pertial penebration, the behavior
of the pusped layer is exactly the sens as that of a
single layer, and (2) at large values of time, a
senting plat of drawlow wereas the yields a
straight line whose slope is only a function of the
axo of the two translandvicies. A pathod is
proposed for the interpretation of pump-test data.
(Rydraulies of veils, multi-layer aquifers)

Mater Resours Res., Paper IMU066

Shid Limblesy
Charle Lare REVISITED: CONCENTRATION CHARGES IN VALUE
COLUMN EADICNUCLIDES, 1947 TO 1821
S. L. Volchok (Environmental Manusemant: Laboratory,
U. S. Department of Energy, New York, MY 100(4), V.
T. Bowen, W. B. Clark and Lary R. Hall

A small smale re-implies of Crater Lake water was extried one (n. 1981. Vater from three depths (extress.) a said 14 m) was obtained and analysis for 'S, 'Sir, '1'Cs and Pristonium. The results indicate that 'H and '1'St quantitatively remain in the vater column and that the lake is well sized. Twenty five secount of the '1'Cs and more than aimsty perwent of the platentum has been removed from the water column presumably into the sections. (Fallow, '38r, platentum).

J. Geophys. Rea., Green, Faper 3C0145

1160 Pamoff and Streamflow Evaluations of Watta Balance Hobels of a Mixed Contres

WATERSTED W. B. Baker, Jr. (Socky Hountelm Forest and Range Experiment Station, Plagateff, Arisons, 86801), J. J.

Experiment Station, Plagutaff, Arisons, 86801), J. J. Regars
Three water balance and yield nodels of differing degrees of complexity were availabled using detained as missil contier watershed in anst-central Arisons. Statistical tests on significat monthly flow volumes are provided with a comparison of 3-year mean annual settlestes of evaportaneprivation and streamflow. One multiple the produced the most biss in similated nonthly flow but produced the most biss in similated nonthly strength outside accounts for 75t of the monthly strengthly streamflow volumes. Statistics for the third model tenerally the between those of the other two models. (Simulation models, mixed confirm).

Nico Paraff and Streamlow ABULER OF PERIODIC STOCKETTO LINEAR RESERVOIRD D. Biraldi (Politoceles Al Mila Linear RESERVOIRD

Since the statistics are developed to applicably and commentative are associated with the parameter factor and the statistics are developed to applicably and the statistics are developed to applicably and the statistics are developed to applicating the transfer of the categories as frequency of the content of the present and the statistics are developed to applicating the technique of the statistics are developed to applicating the technique of the statistics are developed to applicating the technique of the statistics are developed to applicating the technique of the statistics are developed to applicating the technique of the statistics are developed to applicating the technique of the statistics are developed to applicating the technique of the statistics are developed to applicating the technique of the statistics are developed to applicating the technique of the statistic are developed to applicating the technique of the statistic are developed to applicating the technique of the statistic are developed to applicating the technique of the statistic are developed to applicating the technique of the statistic are developed to applicating the technique of the statistic are developed to applicating the technique of the statistic are developed to applicating the technique of the statistic are developed to applicating the technique of the statistic are developed to applicating the technique of the statistic are developed to applicating the technique of the statistic are developed to applicating the technique of the statistic are developed to applicating the technique of the statistic are developed to applicating the technique of the statistic are developed to applicating the technique of the statistic are developed to applicating the technique of the statistic are developed to applicating the technique of the statistic are developed to applicating the technique of the statistic are about the optimization to the spisman that appears the large to absert attemption to the spisman that appears the large to absert at level, ice cores)
Rydrological Sciences J. vol. 28, no. 1.

Rydrological Sciences J. vol. 28, no. 1.

3170 Soow and ice
PAST ATMOSPHERIC ENVIRONMENTS REVEALED BY FOLAR
ICE CORE STUDIES
M.M. Warrow (Schlumbarger-Doll Research,
Ridgeriels, CT 06577)
and E.L. Harrom
The polar ice sheets of Greenland and
Antarntica are unique salimentary environments
which offer valuable information on the cliente
and atmosphoric environment of the past. The
provailing low temperatures, lack of mixing of
strata, and relatively high accountation rates
result in high quality records which may be
resulted in great datail, frequently at the scale
of seasons of the year. Deformation of ice at
great asph reduces the resolution but extends
the available time span to hundreds of thousands
of years. Climatic and environmental information
is obtained from ice cores penetrating the ice
theats and is derived from the composition of the
ice Itself, as well as from chemical ispuritions
and entraped air hundred. Lee core signals man
be related to alimatic variables much as mean
annual temperature, summer waruth, and pene
precipitation rates, past environmental effects
that can be datected from ice core data include
volcants amptions, changes in solar activity,
and the impact of man's activities on recent spow
composition, (Ice cores, olimate, atmosphere,
composition)
Hydrological Sulences J. vol. 28, no. 1.

Eyérological Suiences J. vol. 28, no. 1.

3173 Soil Moisture
MODELING THE REFERENCE OF A THE-DEPENDENT WETTED
PREDICTION ON IMPLITATION FROM EFFEMBLE CHANNELS
U. L. Freyberg (Department of Civil Engineering,
Stanford University, Stanford, CA 94305)
The effects of a time-dependent water operated on the case of the complete of a time-dependent water operated on the case of the case o Assumptions of vertical soil soitsurs flow and the validity of the Green-Aspt model for vertical infiltration. Using a simple channel geometry, an analytic sointion is found for the case in which the gravitational component of soil moleture flow any be supported as a fifted and the general case. Application of the model demonstrates that cross-asotional infiltration, that is, infiltration per unit length of chemnel, is a templar function of soil properties, channel geometry, and hydrograph shape. For the channel geometry considered, the divect effects of verlable water presents at the ground aurface are overatedowed by the effects of verlable water presents at the ground aurface are overatedowed by the effects of variation in the wated perfects of infiltration rate is quite unitial that their would be predicted assuming ponded infiltration alone. (Infiltration of cean-Ampt., ophesers intended).

MILUTY OF ELEMENTS STOCKETT LIBERA NEWFORD

D. Bireld! (Politorated di Mijano, Milano 2013), Italy).

Very riple properties of the mean and variance of stockets and tenence of exchanging linear same and carried for the case of exchanging linear repervoirs are divised for the case of exchanging linear properties in get aggregat with what is done by practitioners are fairly non linear, these properties are fairly non linear, these properties are in get aggregat with what is done by practitioners between the beight is understanding the seasonal fatter of releases and the long-turn variations occur ing is seen of the regulated large of portions occur in grant agreement. Here operating rule, seasonal season of the regulated large of portions regulated large of portions of the seasonal large of the regulated large of portions occur in grant season of the regulated large of portions of the seasonal large of the regulated large of portions of the seasonal large of the regulated large of political or seasonal large of the regulated large of the regul

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INTERRATION OF SURFACE MATTH With clearly stated NECONECCS ALCED BY SURFACE MATTH With clearly stated NECONECCS ALCED BY SURFACE WATTH With clearly stated of Surface and Control of Paying Paying Italy?

M. Fuggarm (Inglitude of Sydratica, Surface), of Paying Paying, Italy?

M. Gallett, V. Enterla must L. Salate

A study was made of the prostituty of the control of the form of the first of the prostituty of the control of the first of the prostituty of the control of the first of the prostituty of the control of the first of the prostituty of the control of the prostituty of the control of the contro products and power tagether with ancoral different hypotheses about future prices. A finite of elemnt model of the semiconfined aquifer was justified and calibrated; the importance of the return flux from irrigation was two tented. Simulations or exploitation schoes provided a dutailed forecast of the aquifer response to the irrigation decands, (Reservoir, aquifer, management, finite element model)

Sydrological Sciences J. vol. 28, no. 1.

Hydrological Sciences J. vol. 28, no. 1.

3190 Instruments and techniques
EXPRINCES IN WHITORNETTVE PLANTING AND
MARGERST OF WATER RESOURCE SYSTEM:
U. Shawir (Faculty of Civil Engineering,
Technion - Israel Institute of Technology, Unifa
2000, Israel)
The purpose of this paper is three-fold. First,
malifolyactive decision making is viewed no a
philosophy and a process, rather than coruly a
set of procedures and algorithms; while mathematicalion between analysts and decision makers, are
telemented to be accorded to the maccase in their
cation between analysts and decision makers, are
the crucial determinants of the maccase in their
application. The second part of the paper is
devoted to a brief outline of some methodologies
which have been found useful in multiobjective
planning and management of water resources
systems. Finally, the main thrust of the paper
lies in presentation of experience gained in
several studies. (Water resources systems,
planning, management, multiobjectives)
hydrological Sciences J. vol. 28, no. 1.

1990 Instruments and techniques
TERRES IN THE EFFLOPMENT OF HYDROMATRY

S. Starosolsky (Research Institute for Water
Essures Development (VITHK1), PF 27, K-15')
Sudapest, Stangary)
Operational hydrology requires reliable and
accurate instruments and methods of observation.
It is useful to review developments, particularly
those of the last decade. Two milestones of this
development may be mentioned on milestones of this
development may be mentioned Commission on
Surface Water, namely the IARS/UNECCO/MMO
Symposium of Kobless (1970), and the MMO Sominar
of Fadova (1975). In memorating the trends, the
interconnections of hydromatry with natwork Jeniga
and data processing are discussed. Eugentions
are also submitted for further developments
including research and the potential applications
in one particular field, where now instruments and
methods are badly needed, specifically the
membrodes are badly needed, specifically the
memoratement of three-dimensional turnelent flow in
streams and lakes. Problems and results are
introduced in connection with three-dimensional
flow measurement to give an unample for the trend
of development. (Nydrometry, review, turbulent
flow, network design)
Mydrological Sciences J. vol. 28, no. 1.

Rydrological Sciences J. vol. 28, no. 1.

3199 General or miscellansous

80080MC ACTIVITY, MATER RESOURCES AND THE

ENVIRONMENT: A CHALLENGE FOR MYLDOLOGY

G.B. Golubey (UMEP TO Box 30%-2, Mairobi, Kenya)

Rapid economic devalopment and population

growth exert great pressure on hydrological,

wrotken/sedimentation and biogeochesical cycles.

The cycles are closely related, with the hydrological

gical cycle having the lending role in the

first instance only vater aspects of the impact

of human activity are discussed; namely, the

roles of vator withdrawals, renervoirs and

transfers as compared with the natural components

of the water balance; impacts of irrigation and

agriculture in general; the problem of closed

lakes; water management problems streaming from

the current water resources nituation. This is

followed by a discussion on impacts of human

activity on sater and erosion/sedimentation, with

particular asymmiss on consequences of nuricul
ture. Then there is a discussion on impact, of

economic sativity on water and hydrochemistry;

changes of obscient transport by rivers;

changes of simming the nucle for an active

control of water resources and the hydrological

regime on a large scale. The control inevitably

in the based on th

One total or to the same The control of the control of the following the control of the con

#### Meteorology

1219 Meteorology (the trival Phromens)
one meditors of tracing them fools of infocusing
Shortogramic life that the filting
N.H. Hudson (Amelen Spine Descarch Institute, Locks,
15, Ch. Sant Lymphy, Brownish, N. Drangele and E.
Lecter
We report the object attent, by means of billockeramounts, of three class of modular authorology.

We report the shierrichtoms, by some of billowier, arosers, of three is not of monioni tratosphenic circular field structures at high latitudes, is all three rises; a region of domested directle field is flanked by regions with upward field, in out of the three cases, the central domested field in the attempt them the average fair-weather field, because of the region of the structures are observed only some this of the tire. It is the fields, hillowed, it is the tire, it is the fields, hillowed, it could not be a field of the structure. Taper 10.0236

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Migh W. Filtereser Howevers Livermore National Laborate
F.O. How 80% Livermore, "A 34550
A tuberial review is presented of our underlandy of
strategiberic High and the processes controlling it is
strategiberic High and the processes controlling its place with
equipment and include reported the control.
Paradoxes and consideration of the stratespheric High My
opposes in require.

resolved. Resolution of the stratospheric 150 by opposes to require.

1) Fifther that the only of our current data productive and indicating fulfitudinal gradient before the presumed by the other man from the presumed by the product of the first are stratespheric table 150 in the polar regions.

2) Find it also provides an indepresentable exampled in the production of the first immediately above the tropical respectation of that there is a stratospheric stak for 150 metricular.

feedom.

3) First there exist within the terposphere a new and terposphere and different from or in addition to the tropical fropping to traff for drying air to the mixing ratios found in the less strain were. strategory of conditions such as these are rather; Satisfaction of conditions such as these are rather; reconcile a rather large mass of puriling observations of Satisfaction of 3) would also permit tropophule; strate-pheric flow of air through the middleducture tracks geor, a cost suggested by minima in Og pida (Strate phorie water suggested by minima in Og pida (Strate phorie water suggested a cost elevatation, limited eterodecisco. election, limited circulation.

J. Geoglion. Heat, Science, Paper Round.

1340 General elecations
VARIATION: PLANDARIMENT ABAINAR BERKETTA ON MARKA
AND RELIGIAL OF ALTO ALLES AND THE LEGAR OF DAY
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and Layliconymital Removing Inc., 840 Henorial Rich
Cambridge, DA 0 (1992)

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Rough Sea Surface

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PERSONALIA

Ekaterina Nikitichna Blinova Academician Evgeny Konstantinovich Fedorov

OHRONICLE

Sarkisyan A. S. Conferences on Climatic Aspects of Variability of Oceanographic Characteristics (Tokio, May 11-22, 1981)

ated with sessonal changes in the major jat streams of the two hamispheros, with the larger of these changes occurring in the Northern Esmisphere. Non-sessonal changes in M smerge from the imbalances among regional variations in momentum, with the largest contributions on time scales less than a year coming from the regions 10°-25°B and 20°-35°N. (Atmospheric momentum, certh J. Geophys. Rea., Green, Paper 300116

3745 Gravity waves, tides, and compressional waves
THE FIRE STRUCTURE OF THE STRATOSPHERIC FLOW REVEALED
BY DIFFERENTIAL BOUNDING
J. Barat (Sarvice d'Aéronomie du CRES - 91 370
Vertieres le Suisagon - France)
Wind shear measurements over 30 to 130 m vertical
distances have been performed in the stratosphere by
using balloons executing vertical excursions with very
small vertical velocity. Clear air turbulence is also
detected. The wind shear vector rotates generally in
the clockwise sense with altitude and exhibits a vertical wavelength of about 1 km. These results are
comparable to those obtained in the ocean and suggest
that long paried instrilo gravity waves are responsible
for much of the veriability. CAT appears to be recomparable to those obtained in the ocean and suggest that long pariod inertic gravity waves are responsible for much of the veriability. CAT appears to be re-lated to shear instability and may act as a maturation machenism of the ways field. J. Geophys. Res., Green, Fepar 3c0119

3766 Interaction of etmosphere with electromagnetic waves POLARIZED MICRONAVE RADIATION TRANSFER IN PRECEDITATION CONTROL OF MANOSPHERES: APPLICATIONS TO MINDOW FREQUENCIES R. Muang and K.M. Liou (Nateorology Department, University of Utah, Sait Lake City, Utah 84112)
A micronewe radiation transfer model taking into account Mie scattering polarization effects is developed for a plane-perallel orecipitating cloudy atmosphere. In the model, the azimuthally averaged Mie scattering phase matrix elements are expressed in terms of double legendre polynomial expansion and the cloud temperature is approximated by a linear function of the optical dapth. The complete solution of the fundamental transfer equation is derived utilizing the discrete-ordinates method for horizontal and vertical polarization components. Using this model, the brightness temperature and degree of polarization for three microwave window frequencies of 19.36, 37.0 and 86.5 GHz are calculated for a number of rainfall rates over both land and ocean surfaces. Me show that the brightness temperature computed for 85.5 GHz using a simple Rayleigh scattering approximation is underestimeted by about 7% for a layer thickness of 4.7 km and a rainfall rate of 5 mm/hr. Effects of the Mie scattering function and non-isothermal cloud structure must both be included for brightness temperature calculations of 37 and 85.5 GHz when thick precipitating clouds are involved. Moreover, we also find that there is a significant degree of polarization for emergent radiation of 19.35 GHz at a zenith angle of 50° under a light ratefall condition over ocean surfaces. Over land supperpart of a pracipitating cloud largely reduces the upward radiances of the 86.5 GHz frequency. (Microway, radiative transfer, remote sensing, cloud). J. Geophys. Ras., Grean, Paper 300144

3770 Particles and aerosols (gas-to-particle

3770 Particles and aerosols (gas-to-particle conversion)
DROPLET PHASE (HETERGEREOUS) AND GAS PHASE (WMNGENEOUS) CONTRIBUTIONS TO SECONDARY AMBIENT AEROSOL FORMATION AS FUNCTIONS OF RELATIVE HUMIDITY P. M. REMAITON AS FUNCTIONS OF RELATIVE HUMIDITY P. M. REMAITON AS FUNCTIONS OF RELATIVE HUMIDITY P. M. REMAITON AS FUNCTIONS (DEPARTMENT OF MINNESOLS). In previous publications (McNurry and Milson, 1982, Atmospheric Environment 15:121 and McNurry et al., 1981, Atmospheric Environment 16:121 and McNurry et al., 1981, Atmospheric Environment 1980, Atmospheric Environment 1980, 1981, Atmospheric Environment 1980, 1981, Atmospheric Environment 1980, 1981, Atmospheric Environment 1982, Atmospher

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Alzberg R. E., Garetsky R. G., Suveldzis P. I. Paleotectonic maps of the platform

areas (methodical aspects)

Aksamentova N. A., Naldenkov I. V., Arkhipova A. A. Siages of formation and airucture of the old platforms basement (with example of the Beloruesia terri-

Dobrzhinetskaya L. F. Is there a complete section of the ophiolitic association in the North Balkai region?

Soloviev V. A. Problems of tectonics of the Middle European Basin.

Burtman V. S. Problem of formation of the Pamir-Punjab syntaxis.

Kurbanov M. K., Rzhanitsyn V. A. The Barth crust structure of Western Turkmentstan by a complex of realest characteristic data. stan by a complex of geologo-physical data.

Bogdanov N. A., Vishnevskaya V. S., Sukhov A. N., Fedorchuk A. V., Chekhovich V. D. Oceanic illatostromes of the western coast of the Aleutian Basin (the

Pilatova N. I., Dvoryankin A. I., Dorogutin A. P., Kuznetsova I. A., Mazhenshte-in F. A., Smeiovskaya M. M. Structure of Cretaceous calcic-atkall magmatic belts of the USSR North-East according to space data

#### Reviews

Kosygin Yu. A.: Review of the paper by I. E. Cubin con detailed seismic zonations.
In: con detailed seismic zonations. M., Nauks, 1980.
Debratsov N. L. A new word in tectonics (on Tectonic Map of North Eurasia, scale 1:50000000)

Meeting «Continental and oceanic riflogenesis»

(Gas-to-particle conversion, Secondary aerosol formation, aerosol chemistry, haterogeneous reaction). J. Geophym. Ram., dreen, Paper MCD22

#### Mineralogy, Petrology, and Crystal Chemistry

DEEP-SEA CORAL AND IN KEIL.

Robert L. Hichel (Scripps Institution of Ceaningraphy, La Jolia, CA 92093) Elien M.

Bruffel

Radiocarbon sessurements ware performed on krill and coral semples collected from the Weddell See during IMSOS '80. These are the first radiocarbon sessurements evaluable from this stee since 1973. These data raveal carbon-la levels for Weddell surface water and southern Meddell Balef water. These data indicate that the radiocarbon levels in surface waters in 1980 were the sense or alightly lower than those present in 1971. In addition, an uncausily low Alac value for shelf water (from coral) at 500 a is avidence that Wart maps Water (WDM) may penetrate such further and more frequently outer the shelf region than had previously been expected. ARIC Crystal Chemistry

4260 Paxagenosis, petrography, and petrogeneats
ORIGIN OF MESOZOIC AND TERTIARY ORAPITE IN THE MESTERN
U.S. AND INDICATIONS FOR PER-MESOZOIC CRUSTAL STRUCTURE; I, MAIDS TO ISOTOPIC STUDIES IN THE OFFICIAL OF THE NORTHERN GREAT BASIN
O. Long Parmer and Lonald J. Darsolo (Department of Earth and Speca Sciences, University of California,
Los Angeles, CA 50024)
MESOZOIC and Textlary granitic rocks in the northern Great Besin (MGB) in Newada and Stah display a wide range of initial say (48 to -18) and 55; (-20 to 4400) values which waty fegularly with geographic position. The data suggest that in the western Great Besin, granites formed vis formastion of mages derived from a LEEZ-deplated mentle reservoir and an inland increasing proportion of continentally-derived suggescitual sediment. In the eastern Great Beasin, the granites appear to be primarily derived from Peccambrian sediment. In the castern Great Beasin, the granites appear to be primarily derived from Peccambrian continental basement with little mantle in input. The vestern sign of the Pracambrian basement is defined by discontinuities in the Br and Md isotopic compositions which occur is east central Newada, 100-200 be east of the \*8 for \*8 for \*8 gr = 0.706 line of Kistler and Paternam (1973). A second discontinuity in Br isotopic compositions occurs in western Utah, and is interpreted as marking a boundary hetween Rh-duplated (granifica)) lower continental crust, to the seat, and beament that has no "deplated" lower crust, to the west. The basesent eng (\*-18) and ago in the NGS appara to be intermediate between that of Wyoning (2.6 b.y.) and Colored (1.8 b.y.). Comparison of the top values of the Hesozoic granite batholiths to values for granites in the mantle-derived mages into the continents crust in the Mesozoic. The data support the concept that mentle magnas are added to continents entity at the ment.

#### Oceanography

4507 Boundary layer and exchange processes ON THE RESPONSE OF A WIND-DRIVEN GURRENT OVER A CONTINENTAL SHELP Sinar Extend (Seismological Observatory, University of Bergen, N-5000, Bergen, Norway). The response of a coastal current forced by a steady wind-stress over a sloping continental shelf is investigated, A Laplace transform technique is used, and it is shown that in the adjustment to a steady state, the response consists of a damped, propagating disturbance, carrying energy offshore and long-shore. This may be associated with shelf waves, but the response is not related to any poles of the image function. The spectrum is continuous, and a discrete set of "normal modes" does not exist.

J. Capphys. Res., Green, Esper 1991e.

4713. Circulation

MEASUREMENTS OF SUBTIDAL FLOW IN THE LESSER

ANTILLES PASSAGES

Paul A. Mazeita [Maval Ocean Research and
Development Activity, NSTL Station, MS 39529)

Thomas H. Kinder, Donald A. Burns

During 1977 we obtained current meter records
for up to 284 days length in the two southernments passages of the Lesser Antilles, St. Vincent
Passage and Grenada Passage. The sub-(nartial
velocity variances accounted for 15 to 773 of
the total record variances and the amplitudes
of these sub-inertial fluctuations were similar
to record means. The depest current meters
(25 to 150 m above bottom) had oscillations of
about a 14 day period, whereas shallower current
coters (greater than 400 m above bottom) were
dominated by fluctuations with greater than 30
day periods. (Straits, Caribbean).

J. Geophys. Pes., Grean, Paper 300215 A507 Boundary Layer and Exchange Procusses
PHYSICAL/BIOLOGICAL STRUCTURE AND EXCHANGE ACROSS THE
THERMOMALINE SHELF/SLOPE FRONT IN THE NEW YORK SIGHT
Robert W. Houghton (Lamont-Doherty Geological
Observatory of Columbia University, Palisadea, New
York 10964) and John Marra
During the susser, the shelf/slope water front in
the New York Bight is thereobaline with strong
temperature and estimity gradients occuring on indpyenals connecting shelf and slope water. The dominant
lateral exchange is wis slope water intrusions above
and below the cold pool, a remment of winter-mixed
shelf water. These (intrusions create suptrocussuit
favorable for double-diffusive processes. Bowever,
measured values of the density ratiq R, over the shelf
imply weak vertical mixing (K, ~ 10^- cs/s^-) but which
is consistent with best sod sair fluxes into the persistent cold pool. Convergent circulation driven by
caballing and vertical mixing enhanced by doubte-

w713 Circulation
PHYSICAL ASPECTS OF A LENGIH SCALE FOR THE GULF
STPEAN )PORT
T. M. Kao (Civil Engineering Department, Catholic
University of Assertce, Washington, D.G. 20064)
A discussion is presented of the physical interinterval of the physical interval of the physical interinterval paper by two and Chensy (1962) to scale
the mea-curface height encoming across the Gulf
Strees Front. Additional results of sea-surface
height anomaly profiles computed from the hydrographic date from fuglisher's GULF STREAM 60 are
also included. In all cases the width of the
anomaly is spanned rather procisely by 2 Å. The
relationship between Å and the internal Rosaby
cafgus of deformst lon Å, In discussed. cabolling and vertical mixing anhanced by Jumbiu-diffusion at the outer edge of the cold pool say be responsible for the abruyt despening of the chicacopyli massimum layer. (Thermoheline front, double-

# radius of deformation \( \), is discussed. J. Geophys. Res., Green, Paper 300120

4713. Circulation

4710 Chemical oceanography RADIOCARBON IN THE WENDELL SEA AS OBSERVED IN A DEEP-SEA CORAL AND IM KRILL

ADTON-MATER OBSERVATIONS IN THE WEST.

7 PACTURE SONS

3. L. Sibtroim (U.B. Gamological Survey, Manlo
Park, California 94025), p. E. Blaceye, and
Stanley S. Jacobs

The Venn fracture mone trough, at 11°8
between 4° and 45°B, is open to the west at
the 8000-m level but is silled at the 4650-m
level on the seat where it interests the
axis of the Mid-Atlantic Ridge. The trough
is filled with Americal Sottom Water (ARM)
with a potential temperature of 1.22°C and

axis of the Mid-Atlantic Ridge. The trough is falled with Antarotic Bottom Water (AAPM) with a potential temperature of 1.32°0 and salisity of 1.82 ppt. The bottom water is thermally well mixed in a marrly homograpus layer about 700 m thick. The great thickness of this bottom layer, as compared with the bottom—water structure of the western Atlantic basin, may result from enhanced mixing indused by topograhic constriction at the west and of the fracture assections. A benthic thermodline, with potential temperature gradients of about 1.2 seeg mixing indused with an about 1.2 seeg mixing account with an about 1200 seters above bottom. A transitional layer of more moderate temperature gradients, about 6.4 mdag mixing like between the benthic thermodline above and the LASW below. The AARW layer whose depth—averaged sumpended particulate concentrations range from E to 19 pg 1.", is consistently higher in turbidity than the overlying waters. At the sastern and of the trough, 140 m below cill depth, very low morthesatured current velocities, with maximums of 1 or mi. vera recorded for an 11-day period. (Abyesal water, ocean turbidity, bottom currents, sixing).

4750 Physical proportion of sammber

J. Geoghys. Ras., Grass, Paper 201988

4750 Physical properties of semester MILES SIRVAGE LATER INSPERVINE AND LAYER SEPTH IN MATER OFF THE ARGENTHAN CORST SILVE Blanc (Departments Desangarafia-Servicio de Hidrografia Naval. Av. Montes de Oes 2124 -(1271)- Capital Pederal - Argentina) Gustavo Goni and Jorge Novalini
Analysis of 26 years of bathythermographic data is used to describe the commercian between the sea surface temperature and the layer depth in the Western Scuth Atlantic off the Argentinian coast. The area is influenced by the presence of two mater masses, Subtropical waters and Subentaratic Maters. A seasonal analysis was carried out for squared subtress of five degrees side. The platting of layer depth versus surface temperature provides two types of patterns. Pridence suggests that they might be related to the presence of eath of the shove mentioned water masses. A clear tendency was found for data distribution in each stheres. The exponential function

Le a exp (bT)

vas found to fit best the dependence of the layer

was found to fit best the dependence of the layer depth (1) on the surface temperature (7). Very different ranges were empirically found for the real constants a and b according to the predominant water mass in each subares. (Layer depth, tempera-

J. Geophys. Red., Green, Paper 201935

A730 Physical properties of sentett TERMODYAMAD PROPERTIES IN IRREVERSIBLE PROCESSES OF SEAVATES.

R. Ends (Department of Applied Physics, Wattonal Defense Academy, 1-10-20 Machitimize, Yokeweks 198, Japan) K. Brigelars.

The theoretical expressions for therepolyness parameters in irreversible progresses of seavater are obtained by using

of the binetic models of hydrated water unlacules around fone and liquid water. Under the assumptions, we obtained the instantaneous (\*\*) and relexational (\*\*) thermodynamic quantities of seawater. The quantity (27/27) of which may be raised into the potential temperature at equilibries, can be divided into the part of rend\*\*. Both quantities (27/27) of and (27/27) of the hydrations around some and free water. (Structural relexation, hydration, potential temperature, seawater) J. Geophys. Res., Green, Paper 100225

section Meddell Bhelf vater. These date indicate that the radiocarbon levels in surface waters in 1980 were the sens or alightly lever than those present in 1977. Is eddition, an uneswally low A're vatua for shelf water (free core.) at 500 a is avidence that there may face (CMS) any penetratic much further and sore freely been separated. The region chan had previously been separated. The region of the

#### Particles and Fields— Interplanetary Space

5340 Shock Waves
NULTIPLE SPACECRAFT OBSERVATIONS OF INTERPLANFIANT SHOCKS: FOUR SPACECRAFT MORIAL
DETERMINATIONS
C. T. Reasell (Institute of Geophysics and
Planstery Physics, University of California,
Los Angelos, California 90024; M. H. Mollott,
E. J. Smith, J. H. King and O. Vaisberg
ISEE-1, -2, -3, IMP-8 and Prophos-7 cheavestions
of interplanetary shocks in 1978 and 1979 provide
five instances where a single shock is observed
by four espectraft. These observations are used
to determine best-fit normals for these five
shocks. In addition to praviding wall determined
shocks for future investigations those data silou
us to evaluate the accuracy of several shock
normal determination techniques. When the angle
between upstress and Journateon beginstic field
is greater than 20°, respectit copinanity can be
an accurate single spacecraft method. Bowever,
no technique based solely on the magnetic sessionsents at one or outliple sites were universally
accurate. Thus, we recommend using ovardetermined
shock pormal solutions wherever roses blye, utificting please coentrecunits, separation reclaims delay received with interplenetary shocks). J. Geoghys. Rus., Blue, Paper JA0240

#### Particles and Fields-Ionosphere

SOO Airglow
THEORETICAL HODELLING OF LOW-LATITUDE HO\*
C. G. Pasen (MAMA/CHPTC, Code 964, Greenbell, Maryland,
20711), F. B. Mys. and B. N. Anderson
The fow-latitude hg\* morphology was inferred from the
2800 A resonance emission observed by the Visual Airglow
Experiment on Atmosphers Explorer E. Date were obtained
over 3 months mear northern winter Solution and selec
maxingue conditions. Latitude-local time contour plots
of ion density were produced in three longitudinal
regions. Theoretical modelling of the Ng\* number
densities was undertaken by moiving the compled
continuity and momentum equations for one major and one
almorion. The calculations reproduced the observed
appearance of largest metal fom densities in the early
siturnoon in winter solution, and number density
profiles that are nearly solutions for one major and one
solur one thing latitudes (2500 km) near dust.
Correlations of high situades (2500 km) near dust.
Correlations of high situades densities with season and
solar cycle are supported larger densities at fixed
altitudes are seen during solar maximum conditions, and
at equinor near sunset. Newtral winds, particularly in
the Wregion, were found to be very important in
detarning the matal ion distribution of high sittendes,
particularly the Wregion tidel originations.

(Mata)
long, morphology, modelling, leg-legitude ionosphere),
J. Geophys. Rad., Blue, Fajer JAO120

3505 Airglow A BOCKEY OSSERVATION OF THE 6300 3/5200 3 INTERSITY PATIO IN THE DAYSTER AUXOMA: INFLICATIONS FOR THE PRODUCTION OF O( $^{1}$ D) VIA THE REACTION  $(^{3}$ D) +  $0_{2}$  + 80 +  $0(^{3}$ D) Richard Link (Centro For Hesserch in Experimental Space

Richard Link (Centre for Research in Experimental Space Science, York University, Denomiciary, Optarin, Camada, NJJ 193)
An emplysis of rocket ANF-VR-Al measurements of the spatial vertation of the 16300/15200 intensity ratio in the daysis claft and polar cap ionosphara is reported. The measured variation of the 16200/15200 ratio is not consistent with significant production of \$300 % emission via the repation  $N(D) + O_2 = 80 + O(1)$ . An upper limit to the O(1) yield of O(1) is obtained for this mechanism.

Geophys. Res., Lett., Paper 21.1796

5515 Auroras

THE DESOCIATIVE RECOMMENATION OF O2\*1 THE QUANTUM
THELD OF O('s) AND O('d))

V.J. Abres (Space Physics Research Laboratory, Department of Annospharic and Commin Science, The University
of Michigam, Ann Arbor, MX 48109), S.C. Selecce,
N.E. Sharp and P.E. Haye

Date from the Visible Airgion Experiment on the Atmosphare Explorer -2 astellite have been used to determine
the quantum yield of O('s) and O('b) from the dissociative recombination of O2\*, A range of values between
0.09 and 0.23 has been obtained for the quantum yield of O('s)
depends of the ratio of algebrase for the quantum yield of O('s)
selected of the ratio of algebrase for the quantum yield of O('s)
say depend on the degree of vibrational excitation of
the recombining 0.\*

The quantum yield of O('s) has been measured to be
1.23 2.64 with no dependence on the electron oxygen
ratio.
1. Compleys, New Blue, Painer 3ACEU ratio. J. Gopphys. Res., Slue, Tager MARIZ

5513 Aurorgs
CONCERNIC SOURCES OF O(1D) IN ADRONAL BLECKER IMPACT
AND DISSOCIATIVE RECOGNIZATION
V. E. Sherp (Space Physics Basserch Laboratory,
Daiwarstry of Richigan, Ann Arbor, Michigan 48109),
D. A. Ortland and R. F. Cagasp
The electron impact and dissociative recombination
source functions of O(1D) in surers are examined. The
data from nine AS-D gaines plus one rocket fright are
accepted it altitudes between 13D be and 333 be. It.

is found that in nighttime surers 90% of the total source function is unidentified below 200 km. Electron ispact (including thermal pleatrons) and dissociative recombination are probably adequate source functions, above 230 km. (Oxygen twi line, photosatry, electron impact, dissociative recombination).

J. Geophys. Res., Blue, Paper 3A0173

impact, dispociative recombination)
J. Geophys. Res., Blus, Faper [A017]

5535 Interactions Retween Waves and Particles
NIE AFFAMENT SPECTRAL BROADERING OF VIT TRANSHITTER
SIGNALS DURING TRANSIONOSPHERIC PROPAGATION
T. F. Ball (5748 Laboratory, Stenford University, Stenford, Call formis 94305), R. G. James, U. S. Insn., and
J. F. Katsufrahis
VLY/ELF slectric field wave data acquired on the
1513-1. [515-11], and ISRE-] salellites deponstrate the
oxistence of a new phanoneous in which initially narrowband (-1 Ha) upgoing signals from ground-beaded VIF
transsiters undergo a significant spectral broadening
as they propaget through the ionosphere and protonosphere up to skitudes in the range 600-3800 km. For
transmitter signals in the range 600-3800 km. For
transmitters signals in the range 16-to-20 km, the
spectral broadening can be as high as 10% of the nonlneal frequency of the input signals. Spectral broadening
accurs only in the presence of impulsive VIF hims and/
or a lower-hybrid-resonance (LRR) noise band with an
irregular lower cutoff frequency and only for signals
whose frequency excauses the LRR frequency at the satellite location. It is often observed in association
with a head of impulsive EIF hims below 700 Hz. In
many cases, the bandwidth of the spectrally broadened
signals is a strong function of the electric dipole
antenna orientation with respect to the local direction
of the centr's Respect for laid. Unusual disparation in
the components of the spectrally broadened paless suggears that the spectral broadening may be due to a
dopplor shift effect in which the initial signals acatter from irregularities in the Fragion and couple
into quasi-slectrostantic Locks of short wave length.
The large doppler shift associated with these short
wavelangth modes produces a significant increase in
the bandwidth of the signal, as observed on a moving
satellite. Since impulsive WI bias and irregular URR
notes bands have been linked to emerged to the
section practice for the part Modes of short wave leng

5599 General (Ionospheric Structuring)
FINITE PARALLEL MAYELEMSTHS AND LONGSPHERIC STRUCTURING
J. L. Spering (JAYCOR, P.O. Box 85154, San Diego,
C411fornia 92138)

Finite possible white results and incorpheric Structuring J. L. Spering Mile Results and incorporated Single Control of the Single Property of the Single Proper

#### Particles and Fields-Magnetosphere

5703 Pow shock waves
A SOURCE OF THE BACKSTREAMENG ION BEAMS IN THE
FORESPACE REGION

June 10 Manual of Manual College Pay N. Isaaks, (University of Haryland, College Fark, Maryland, 20742) C. C. Goodrich, D. Wiasks, and K. Papadonomina

Maryland, 20742) C. C. Goodrich, D. Wissland, 20742) C. C. Goodrich, D. Wissland, and K. Papadopoulos

A new source mechanics is proposed for the "reflected" fon beems observed in the foreshock region of the earth's how shock. In our social the beams of the earth's how shock. In our social the beams originate in the magnatesheasth downstream of the quesi-perpendicular shock transfit on a characterised by two downstream ion populations including high anergy greating fous in addition to the divertly transmitted anisotropic ions. We show by particle simulations that this highly anisotropic downstream ion distribution which, in turn, pitch-angle exists fon cyclotron washs which, in turn, pitch-angle exists the gynating acquire large parallel valocities and move fast enough along the convecting downstream magnetic field to engion. The distribution of sacaping ions calculated by using the pitch-angle scattered loss, as a source, by using the pitch-angle scattered loss, as a source, because the how shock into the upstream bedoesn a beam with a large temperature smisotropy in the distribution of sacaping ions calculated bedoesn a beam with a large temperature smisotropy in the same than the convecting downstream same account of the solar wind walceity. A significant result is the presence of the markum of a show thich no ions can escape, where a show which no ions can escape, where searing to the solar wind. These constitutes are in general spreament with the ISER observations of the solar wind. These observations of the solar wind. These observations of the solar wind. These observations and the solar wind. These observations and the solar wind.

3755 Finance instabilities WARLESTIC RECTRON PARTICIPATE OF THE STABILITY OF ENERGETIC RECTRON OF THE STABILITY OF ENERGETIC RECTRON OF THE STABILITY OF ENERGETIC RECTRON OF THE STABILITY OF ASSTRUCT RESERVOIR STABILITY OF THE STABILITY OF THE

All Old Caradal, 2.A. Whiles, A.G. Petranes and W. A Mike Black Brant Y mochae was launched from the huschill Learner Range (Manitoka) on Becamber 3, 1979 rocket price of the wasterness or cleated surgest are. The each created state and the such create priced consisted of two separable sections, was and charges particle determine, An alsotron made waster and the major spring produced a pulsed electron carriag the major spring produced a pulsed electron spring with seargies of 1.9, 6 and 8 key at 1, 10 and periods objected from the Light are used to descending the special distribution of Defruits and charged from the special distribution of petroless are all statements and successful time. The radial the principal search periods special distribution of petroless are all time. The radial the principal search was grantageness of the perhaphytics were found to accide with the principal search was grantaged and search with

were also dependent on the beam impaction engia. On magnetic field lines mear the gun, the induced return electron energy spectrum is characterized by a monotonically decreasing incensity with increasing energy out to the approximate beam energy. At increasing distances across field lines the energy spectrum takes on a monoemargetic appearance packed mear the beam energy. The incense flux of low energy electrons observed on field lines mear the rocket are shown to be accelerated ashimats, whereas the particles at or mear the beam energy and at large radial distances, are presumably heam primaries. The subject thereof in plants was not measureably affected by the beam while the electron temperature increased during gun pulses. Results from this flight are compared with the corresponding observations nade in a large vacuum tank significant with the beam-plant match significant with the beam-plant instability observed in the Laboratory. (Flamma instability also, particles precipication). J. Geophys. Ros., Blue, Paper 140125

5755 Plasma instabilities
OBSTRYATIONS OF LAR HOISE WITH BANDED STRUCTURE BY THE
SOUNDING ROCKET S29 BARIUM-GEOS
Hannu E. J. Koskinen (Uppsala Janospheric Observatory,
5-75446 Uppsala, Sweden), Gunnar Holmgren, and Paul M.

S.75464 Uppsale, Sweden), Gunnar Holmgren, and Paul M.
Kintner
The density fluctuation and electric field data from
the Swedish sounding rocket 529 Barium-BEOS shows a
broad electrostatic noise band near the lover hybrid
requency. The noise is related to the spin of the
rocket and estands well below the local lower hybrid
resonance frequency. Above the altitude of 300 km the
noise shows banded structure roughly organized by the
hydrogen cyclotron frequency. Simultaneously with the
banded structure a signal near the hydrogen cyclotron
frequency is detected. This signal is also spin modulated. The character of the noise is discussed in
comparison with the probable free energy sources and it
is suggested that the noise is locally generated by the
rocket payload disturbing the plasme. If this interpretation is correct, we espect plasma wave experiments on
short spacecrafts to observe similar phanomena. (Lower
hybrid resonance, density fluctuations, free energy

J. Gsophys. Bes., Blue, Paper 340126

MAGNETOTALL
Validation J. Haikkils (Center for Space Sciences,
University of Texas at Dellas, Richardson, Texas
75080)

University of Texas at Dallas, Richardson, Texas 7,0800. It is pointed out that the boundary layer plasma rout somehow leave the segmetospheric system. We propose that the boundary layers on the dawn and dusk flanks are continued into the far aggestorall, becoming joined together far downstreen, still or closed ungoeic fleid lines. Within the combined layer there would be a dusk to dawn steethed field for smillsumward convention (as is the case for the boundary layers on the days and dusk flanks searer to the search). It is suggested that the boundary layer flew is so manually the the flow itself can generate the right electric field for continued flow. Howe of the plasma in the martle over the polar caps would also be convected out in a similar manner, tather feeding the plasma sheet. There would be a suggested point becoming the plasma skeet. We could be any boundary or mantle plasma diffusing earthwerd of this point becoming the plasma skeet. It is deduced that no steady state solution is possible. (Sientric fields, magnetotall). Geophys. Res. Lett., Paper 310205

# Physical Properties of

6120 Equations of state
AMMARGUREITY OF TERRE HIMERALS AT HIGH TEMPERATURE:
FORSTRAITE, FAYALLTE AND PERICLASE
O. L. Anderson (Tastitute of Geophysics and Pianetary
Physics, Guiversity of California, Los Angales, Los
Angales, Culifornia, 90024) and I. Susmit
Escent date on Eg (the adiabatic bulk modelus) and
a (the volume coefficient of thermal expansion) vs
T, (temperature) at high temperatures (2000c < T
< 1000c) have been published or are in press.
These data, taken at ambient pressure, extend the
measurement of single-typalic lastic constants for
temperatures, fayalite and forsterite to record
The high temperature ambarmonic measurement

pariclase, fayalite and forsterite to record
tamparature.

The high temperature substractic to record
The high temperature substractic properties of
forstarite and fayalite are presented for the first
time to this paper, and they are compared with similar
proviously poblished data for lago. The anharmonic
the Grinetes referred to above concern the dependence of
the Grinetes referred, Try (the thermal,
if the anharmonicity in the said to be full
proportional to T. at high T, then the substraceity
In Rym is said to be all.
The substracticity termined by these

The ablato be mil.

The ablamonicity distrained by these experiments indicate the minerals are not slike with repard to their properties Y. Pra and Cy. Y vs Tat and Cy. The seventies of their properties of their seventies of their seventies of their seventies of the slight three sharals, but the effects are opposite in all three sharals, but the effects are opposite in fayalite and forsterite in such a way that an ablation should be absent in citizen. For Pra at one bar, enhancedity is detectable and positive in forsterite, absent in fayalite, and detectable and negative in periclass. It would be slight in citizens. In all three solids, anharmonicity in Cy is pronounced and positive.

J. Geophys. Res., Red. Paper JB0140

### Planetology

Fig. 2. South of the ampeteprons with Coopley and all the service of the service

Molodensky S. M. On the upper bound for viscosity of the Earth's core Vinnik L. P., Yegorkin A. V. The low velocity mantle layer bounds the old plat. Vinnik L. P., Yegorkin A. V. The low velocity manner layer memeath the old platforms from extended seismic profidings.

Pivovarova N. B., Slavina L. B. Methods of calculation and stability analysis
of three-dimensional P-velocity structures. Kamchatka case study.

Burmin V. Yu. One-dimensional numerical kinematic inversion of refracted wave

Physics of the Solid Earth

Volume 17, Number 12

travel-time curves

Nikitin A. N., Volarovich M. P., Parkhomenka E. I., Gulikov M. I. Measuring 40.

Nikitin A. N., Volarovich M. P., Parkhomenko E. I., Gulikov M. I. Measuring angular variations of piezoelectric effect in samples.

Savinsky I. D., Briskin V. L., Petrova A. A. Galenlation of gravity and magnetic fields on inclined and vertical planes in the lower half-space in geoelectrical problems.

Schubisova N. S. Continuation of transient electromagnetic fields for applications in geoelectrical problems.

Golubisova N. S. Anomalies of electromagnetic field over an isometric depression Scheberbakov V. P., Fedotova M. A. Effective fields of interactions in a single-domain grain system during thermally activated and hysteretic processes.

#### SCIENTIFIC COMMUNICATIONS

Latynina L. A., Karmaleyeva R. M. Tidal deformation measurements in the Garm observatory, Tadzhik SSR
Panasonko C. D., Kolomiyets A. S. Tiltmeter recordings of tectonic fault motions in mountain area

Aranovich Z. I., Mclamud A. Ya., Negrobitsky S. A. Pulse calibration of broad-

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6599 Camerai (Planetology)
VENUS' MUSTITUE HORIZONTAL PLASMA PLON, "MAGNETIC
COMMISTION", AND HORIZONTAL PLASMA PLON, "MAGNETIC
COMMISTION", AND HORIZONTAL PLASMA PLON, "MAGNETIC
COMMISTION", AND HORIZONTAL PLASMA PLON, "MAGNETIC
G. G. Mayr. B. A. Curtis and H. A. Taylor, Jr.
A persistent Feature of the nightide Venus
ionosphere is the existence of localized wagnetic field
aligned columns of deplated ionization—let, "holas"
anhauced, By analogy to the earth's auroral regions it
has been informed that parallel electric fields can
plasma loss wechanism at night is downward transport
into the lower ionosphere where chemical deplation
occurs. A simple rectilinant two disametonal MOD model
is used to explore the effects of field aligned plasma
weak magnetic field. By parameterising field eligned
tions, it is shown that the abrupt horizontal enhance—
manners of the vertical magnetic field as well as abrupt
decreases of the plasma density to very low values—
the presence of field aligned losses. The horizontal
decrease in plasma density to very low values—
the presence of field accurs in sonjunction with a
decrease in plasma density occurs abruptly when the
magnetic field occurs in sonjunction with a
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magnetic field intensifies to such a level that the

6599 General
ON THE EQUATORIAL TRANSPORT OF SATURE'S LOROSPHERE AR
OF DELVEM BY A DUST-RING CURRENT SYSTEM
W.-H. TO REAL-Planck-Institut für Abronomie,
D-1411 Katlanburg-Linden 1, F.R.G.)
D. A. Mendis (Canter for Astrophysics and Space Ecisnee,
University of California, San Diego, La Jalla, CA 92093),
U.S.A.)

J. Geophys. Res., Blue, Paper 3A0110

6545 Interfor of planata

REPLY TO THE CRITIQUE OF REASKNEERS a BILLS ON 'ALASTIC

A. CASEANANCE AND DOMAIN (Grouped in Recharcia id

Goodsta Spatials, Centre Wational d'Etudos Spatials,
In a pravious arody (Caseanave and Domain), 1981, we

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### Seismology

6975 Structure of the earth's interior below the spec A SHISMIC PROBEL OF A PARTIALLY POLTEN INNER COMB.
B. Loper (Reophysica) Fluid Dynamics Institute, Florida State University, Tellahasses, Florida, State University, Tellahasses, Florida, State University, Tellahasses, Florida, State Theoretical Physical Physical Physical Physical Physics Canada Particles Physics Canada Physics Canada Physics Physics Canada Physics and D. R. Pearn (Department of Applied Mathematics, Theoretical Physics, University of Cambridge, C

taining to geographically limited regions only (including also the NOBSAR observations) are partly conflicting unless lateral variations exist. On balance, current thermal models appear to be consistent with (but not required by) the present saismic evidence. J. Goophys. Pess., Red., Paper 380196 el., 1982a). Geophys. Res., Red, Paper TRAIGI

#### **Social Sciences**

7310 Economics
PRICING AS A POLICY TO REDUCE SEMAGE COSTS
Michael Strudius and Tuar E. Strand, Jr. (Department
of Agricultural and Resource Economics, University
of Maryland, College of Agriculture, College Park, of Maryland, College of Agriculture, College Park, Maryland, 20142)
Coupliance in Maryland with the Federal Clean Water Act will cost an estimated 5] billion. By charging a modest water/sewage fee for residential water use (52 per thousand gallone), it is shown that sewage flows could be reduced, resulting in a templiance cost savings of 321 willion. The cust reduction accurred oven though only one-third of the numbel-pelifics (heavy pur capits water weers) had to beer the increased price. Pricing policies are suggested as a method of reducing the costs of environmental standards.

Natur Resour, Res., Paper 241719

7310 Economics (Irrigation Water Mixing)
ECONOMICS OF IRRIGATION WATER MIXING WITHIN A PARK
FRAMEWORR

E. Feinerman (Department of Soil and Environmental
Sciences, UE Riverside, Riverside, California, 92521)
and D. Yaton
Linear programming models, deterministic in the short
run and stocksetic (random rainfall) in the long run,
simud at guiding annual decision-making with regard to
crop mis and sellme irrigation water mixing from various
sources within a farm framework, are presented. The
short run model incorporates the physical, biological
and sconomic relationships involved in one endogenous
system and enables an in-depth analysis of them, but is
limited to a single year. The long run model considers
the effects of the short run decisions on the future but
several relationships are incorporated exogenously. The
short run model's results are utilized for the determination of some of these predetermined relationships.
The models are applied to a potencial farm situation in
southern largel. The results provide priorifies in the
allocation of water and soil plots of varying salinity
levels and expirical estimates of the shadow prices and
the rates of substitution between the limited resources
Vator Resour. Res., Faper 180224

#### Solar Physics, Astrophysics, and Astronomy

7720 Electromagnetic radiation
RADIATION FROM A MOVING FOINT-CHARGE IN A DRIFTING
AMISOTROPIC PLASMA
K. Yasmooto (Department of Computer Science and
Communication Engineering, Faculty of Engineering,
Kyushu Daioversity 16, Pukuoka 812, Japas)
The radiation from a uniformly moving point-charge in
an anisotropic cold plasma drifting along a finite
eaternal magnetic field is investigated, on the basis
of the electrodynamics of moving media. In general the
radiation consists of two waves, i.e. the ordinary and
extraordinary waves. The analysis shows that me the
drift valocity of the background plasma lacrasess and
approaches to that of the moving mource, the radiatiod
energy of the ordinary wave is reasonantly enhanced and
the Corenkov ray background energy of the ordinary wave is reasonantly enhanced and
the Corenkov ray background energy of the ordinary wave is reasonantly enhanced and
the Corenkov ray background energy of the ordinary wave is reasonantly enhanced and
the Corenkov ray background energy of the ordinary wave is reasonantly enhanced and
plasma, electromagnetic radiation).
Rad. 5ci., Paper 241885

7760 Radio Astronomy
JOENTIFICATION OF RADIO EMISSION FROM THE TO FLUX TUBE
A. C. Riddle (700 front place, Boulder, CO, 80302)
Many theories and observations suncest that Jovian
Decametric Radio Emission is guarested in flux tubes
that osas through to or that pass close to lo's orbital
arch Mondre: Comparison of theminand observation is
hindered by lack of inordiagne as to which specific flux
tube is responsible for a particular amission. Emission
from, or close to, the instantaneous to flux tube has
now been identified. This makes upsaible a mapping of
emissions onto the causative flux tubes for a
significant range of Jovian longitudes (240°- 360°).
The way is now open for a more direct comparison of
current theories with the observations.
J. Geophys. Ras., Blue, Paper 241489

7770 Sunspote
THE GREAT SOLAR ANCHALY CA. 1780-1800: AN ERROR IN COMPILEMS THE RECORD
C. P. Sonatt (Bapts of Flanetery Sciences and Lunar and Planetery Laboratory, University of Arisona, Touson, AZ 85721)
Tha view that the ammapot time index sequence is of lessaned validity prior to about 1850 is shown to be consistent with an error in the 1780-1800 time parted whan phase, offset of the Hale carrier simusoid from sero mean, and the amplitude modulation envelope all show a lack of conformity with respect to the tender minimum. This is consistent with an error which delays one or more il year cycle minims but subsequent consor more il year cycle minims but subsequently recovers phase. This type of error creates a strongly coherent set of companion changes in offset of the carrier from zero seem and in the suplitude modulation envelope. (Sumspot, index, error).

J. Geophys. Res., Blue, Papar 340127

Biso Flate Tectonics
AR EXPLANATION FOR CONTRADICTORY GRODEFIG STRAIN AND VAULT FLARE SOLUTION DATA IN WHSTERN MORTH AMERICA Marc L. Sher (Department of Georgiances, University of Arizona, Tunson, Arizona, 35721)
In a few areas of western Worth America the principal strain asimuths from geodetic strain measurements differ dramatically from the principal strain difference and the form of the difference may be related to the smount of strain measured by each technique.
The skrain relieved in an earthquake is about two orders of asgottade greater than that observed by geodetic measurements taken over accrecing the layer. others of magnitude greater than that observed by geo-datic magnitudents inhan over approximately a seven year time span. Strain measurements may thus sense short-tern fluctuations in strain, while earthquakes may swarege them short-tern fluctuations responding to the total strain sectumilated to produce a more reliable massure of the longer-term testonic strain. (Strain, Strain, Lactonies). strass, tactonics). Geophys. Res. Lett., Paper JL0097

Sijd Heat Flow
DEEP CRUSTAL GEOTHERMAL MEASUREMENTS, HOLE 304B,
COSTA RUGA EIT?
Keir Secker (Deep See Drilling Project, Scrippe Institution of Oceanography, La Jolla, California 92093),
M. C. Langeach, R. P. You Harman, and R. H. Anderson
We report an extensive suite of geothermal measures
ments in the despent borehole yet drilled into the
oceanic crust, Hole 3048 of the Deep See Drilling
Project. Located in 6.7 m.y.—old crust of the Costa
Rica Mift, Hole 504B was cored during Legs 69 and 70 in
late 1979 and Leg 83 in late 1981, to a total depth of
late 1979 and Leg 83 in late 1981, to a total depth of
late 1979 and Leg 83 in late 1981, to a total depth of
legs, download températures were longed il times, and
the thermal conductivities of 239 medient and baselt
samples were measured. The results indicate a dominantly Conductive index of heat transfer through the
complete specion, at 190 ±10 mi/m². This is consistent
with the predicted plate heat transfer and the hypochasis that the thick mediment down acts as a seal
baseaunt
language that the thick mediment dever acts as a seal
baseaunt sydouthermal circulation of seasurer to
For over two years after this sediment seel was penntrated, borshole temperatures, were nearly isothermel to
flowing down the flow into the upper 4100 m of baseaunt
Tala downhole flow was driven by the underpressure of
possibly bydrythermal crigin (Anderson and Zoback,
1992). The flow rate, dedressed from 6000-7000 L/ht. in

late 1979 to about 1500 Z/hr. two years later; alto-surbar over 30 x 10° kg of sequences has been drawn into the beatment. We setimate a permeability of 26 x 10°10 of for the roservoir in the upper v100 m of besenant. This rome assess to correspond to a layor of high apper-ont persety (Secker, er al., 1982), which has been centalizely identified as a thin Layer 24 (Anderson, et al., 1982a).

LROS. R.W. Embley (National Ocean Survey/NGAA, Rockville, Maryland 20852), M.A. Hobert, R N. Anderson, and D.

J. Geophys. Rus., Fed. Paper 281358

#### Tectonophysics

# Volcanology

8130 (Heat flow) ANOMALOUS HEAT FLOW IN THE HORTHWEST ATLANTIC: A CASE FOR CONTINUED HYDROTHERMAL CIRCULATION IN 80-M.F.

R.W. Embley (National Ocean Survey/NOAA, Rockville, Maryland 20852), N.A. Hobart, R.H. Anderson, and D. Abobtt
A detailed study of a 60 . 150 km area at 60°N; 24°N at the eastern end of the Bares Abyssal Plain indicates that hydrothermal circulation is still active in the 80 m., 40. P. oceanic crust. The fifty-eight heat flow measurements made during five stations in the area have rovealed; (1) constant heat flow over the abyssal plain (56 mim²), (2) a cyclic heat flow over the abyssal plain (56 mim²), (2) a cyclic heat flow over the abyssal plain; (56 mim²), (2) a cyclic heat flow over the abyssal plain; They are recognized anomaly of 710 mtm² over one of several small dozes which protrude from the abyssal plain. They are recognized from surface echo sounders by an abrunt disappearance in the abyssal plain subbottom reflectors, but on nearbottom pinger records they appear as steep-walled structures which are covered by -10 so of sediment (compared to -75 raters on the surrounding abyssal hills). From analogy with active ridge crosts, these features are probably small volcanoes.

The heat flow anomaly over one of the domes is matched well by a finite element convection model with the following characteristics: (1) recharge at one basement outcrop and dishcarge at another, (2) 300 meters of sediment fill between outcrops, (3) permeabilities of lu-"Oxe" for basalt and 10°-10m\* for sediment. In other words we believe that there is very effective convective heat transfer within the crust and out of the relatively percebbe, thinly sedimented basement dowe, resulting in the local, high heat flow. Overall, the results from the hares survey vividly show the age independent muting effect of heat transfer veries from ourely conductive in the more thickly sedimented abyssal plain areas (-300 sediment to abyssal hills (-75 m sediment cover) to a very large thermal anomaly over the small cover). The domes are possibly inactive basement chinney drilled at 050P site 417A.

Alta.

J. Geophys. Rus., Ped. Paper 281358

8150 Plate tectonics

AMDDDING TEPRANES IN SOUTHERN ALASYA: THE ALEUTIA

MICROPLATE AND REPLICATIONS FOR THE DEPRING SEA

M. d. Nariou (U. S. Geological Sorvey, M45 Middlefield

Riv. Monio Park, Celifornia 940251, and A. K. Cooper

Paleona-metic and quelogical data suggest that Each

of southern Alaska is a collage of

tectonostraticaphic terranes which originated in

Massocic time at peleolatitudes for south of their

present position The time of dooking of the

terranes against oratonic Alaska is a critical to

defining their amalgamated size and extent during

their nor theard motion as well as their role in the

avolution of the Bering Sea.

The of the largest of the tectonostratigraphic

terranes, the Pontasufar terrane of moth contral and

southwestern Alaska, antends offshors along the outer

heriod Soa continental carqin (Beringta).

Paleorapatic lara suggest that this terrane has moved

northward through all of Conozolc time, but geologic

clare imply that the terrane had decreted to Alaska by

the und of the Manozolc. In mariy Conozolc time the

sastorn part of the Aleutian arc appears to have been

superimposed on the Peninsular terrane, and postulated

northward Conozolc antion of the tarrane would

therefor have required northward motion of the arc.

The accretion models, based on dooking these for

terranes in Alaska, are proposed, and they illustrate

that large areas of the abyesel Bering Sea, the Alaska

Peninsula, the Aleutian arc, and the Peringian margin

may be part of a superterrane or storoplate called

Almotth. Model to tell the following these for

southern Alaska, the Alaska Peninsular terrane is late

Conozolc, which implies that the Alautia adroplate

after the aloroplate had docked. In codel 8, the

final docking time of the Peninsular terrane is late

Conozolc, which implies that the Alautia adroplate

in this model is mede up solely of the abyesal Baring

Sea (Sola plate), which presumbly docked at the same

time or elightly after the Pe

J. Geophys. Res., Red, Paper 281710

8150 Terconophysics (flate Tectonics)
RCCHARICS OF FOLD-AND-TURNST BRITS AND ACCRETIONARY
VEDOES

Dan Bavis (Department of Earth and Placetary Sciences,
Messachusetts Institute of Technology, Cambridge,
Messachusetts (1919), John Suppe and P.A. Dahlen (both
at Department of Geological and Geophysical Sciences,
Princeton University, Princeton, New Jersey, 08546).

The overall mechanics of fold-and-chrust belts and
accretionary wedges slong compressive plate boundaring
is considered to be analogous to that of a wedge of
soil or slow in front of a moving buildozer. The
material within the wedge deforms until a writical
taper is accaised, after which is alides stably, contiouing to grow at congrent taper as additional material is ancountered at the tape. The critical taper
is the shape for which the wedge is on the verge of
failure under horizontal compression everywhere, including the besal decollement. Common silicate sedimonts and vocks in the upper 10-15 be of the crust
have pressure-dependent brittle compressive attempts
which can be approximately represented by the empirical Coulomb failure criterion, modified to account
for the weeksning affects of pore-fluid pressure. A
simple analytical theory that pradicts the critical simple analytical theory that pradicts the critical tepers of subserial and subserial Coulomb wedges is developed and tested quantificatively in three ways: (1) Laboratory-model experiments with dry send match the theory. (2) The known surface slope, basel dip, and pore-field prassures in the series fold-and-thrushelt of western favious set used to determine the effective coefficient of internal friction within the wedge. If a 1.01. consistent with Newticel manufact. balt of weather Taiwan are used to determine the effective coefficient of internal friction within the wadgs, y = 1.03, consistent with Syerias's espirited law of wilding friction, y = 0.05, on the bass. This excess of internal strength over head friction augusts that although the Taiwan wedgs is highly deformed by indricate thrusting, it is not no pervasively fractured that frictional eliding is always possible on surfaces of optimus orientation. (3) Using the shows values of h, and y, we predict kubbart-lubey fluid-pressure ratios A = h for a number of other active subsarial and subsarian suggestionary wedges hased on their observed tapats, finding values averywhere is excess of hydrostatio. These predicted overypressures are reasonable in light of patrolaus drilling experience in general and stres with mearby fragmentary well date is specific wedges where they are available. We conclude that fold-and-thrust noise and accentionary vadges have the methanics of buildoner wedges in compression and that normal leboratory fracture and frictional strengths are appropriate to monatain-building processes in the depart crust, show the britational strengths are appropriate to monatain-building processes in the depart crust, show the britational strengths are appropriate and real state of the part of the strengths are appropriate.

150 Tectonophysics (Figure Testeniss)
A DEATIED STORY OF THE CORE OFFER OF THE
JUAN DE FULL RIDGE, EVOLUTION OF A PROPAGAFINO RIFT
H. P. Johnson (Sch. of Comm. WH-1G, Univ.)
of Manhington, Seattle, Ma 98189), J.L.
Farsten, J. R. Dalaney, E. B. Davis, R. G.
Christa and R. L. Chasa
The Cobe Offers on the northern parties of
the Juan de Puis Sidge has been identified
as the tip of a portneyed physessishing rift
(Mey and Mileson, 1982), Map complishing rift
mignatic and selected data from the contributed and selected data from the comcruises, dafine the present jetter of spreadcruises, dafine the present jetter of spread-

### Physics of the Solid Earth

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Aleksidze M. A. The Stokes theorem for the case of many isolated bodies.

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ing and volcanism on the two ridge segments abuting the Offser and permit detailed modeling of the recent evolution within this transfore zone. The axis of treest spreading on the southern ridge bends from the form of the country o

INVESTIGATIONS OF A VEHE-MATTHEWS MAGNETIC LINEATION FROM A SOBMERSIBLE: THE SOURCE AND CHARACTER OF MARKET MAGNETIC ANGULIES K. C. Macdonald, (Department of Guological Sciences

and Marine Science Institute, University of California, Sants Berbers, California, 9106), S. P. Miller, B. P. Luyendyk, T. M. Atwater and L. Soure We report here the first attacept to directly map the boundary of a Yime-fatthews amounted atripe on the sea floor. Our objectives are to study the prosession occasion coretal accretion as recorded in the reversal transition come and to investigate the formation of the amments occase of vine-Hatthous ampactic amounties. Our deep-tow and ALYIN-based magnetic amounties. Our deep-tow and ALYIN-based magnetic source of vine-Hatthous emphetic and the flanks of the East Prooffer Rise near 27% while the sea-level ampactic anomalies are less than average in district for the East Prooffer Rise, a "chreadisensional" inversion of deep-tow data reveals a sharp, artike-linear polarity transition less than 1.8 km wide (Macdonald et al., 1980s). These assurements have been augusted by counting a vertical assurements have been augusted by counting a vertical assurements have been augusted by counting a vertical assurements there exists a surprise of the boundary, we find that mearly every magnetic target has the correct polarity, i.e., the same polarity as the regional ammental linearies, the same polarity as the regional ammental linearies, the boundary occased to polarity fransition in the outeropping velocate section is sharp and linear among strike, delimented in some cases by a clear geologic context of opposing flow fronts of different ages. Several weakly ampactical of colority transition in the contemporal weakly ampactical of an arvering. The reversal boundary mapped on the services from Milling fat time in which the geomagnetic field was reversing. The reversal boundary mapped on the services from Milling the ine in which the geomagnetic data. This offest provides a souns for estimating the spilower of law way from the agreement suggest that of one deep-tow and ALVIN measurements suggest that of one of equal to intrusive and plutonic rocked was 2000-2000 as wide. This dete J. Geophys. Ros., Red, Paper 282003

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